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O efeito das modificações das regras no judô entre os ciclos olímpicos 2016 e 2020:
diferenças temporais entre categorias de peso e sexo em combates internacionais

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Tese apresentada ao Programa de Pós-Graduação em Educação Física, da Universidade Federal de Juiz de Fora, em parceria com a Universidade Federal de Viçosa, como requisito parcial à obtenção do título de Doutora em Educação Física.
Área de concentração: Exercício e Esporte.

Orientador: Dr. Ciro José Brito

Coorientadora: Dra. Bianca Miarka

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Dedico este trabalho à Deus e à minha mãe:
fontes de inspiração e apoio para continuar
vivendo e superando cada queda da vida.

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RESUMO

Introdução: Esta pesquisa verificou os impactos das modificações das regras do judô dos ciclos olímpicos 2016 e 2020 no tempo total, fases temporais e relação esforço-pausa de combates internacionais, considerando as sete divisões de peso em ambos os sexos. Foram produzidos 3 artigos de revisão (uma narrativa; duas sistemáticas com metanálise) para compreender a evolução das regras e estrutura temporal de combates de judô. **Metodologia:** Analisaram-se 2.712 vídeos de combates internacionais de judô em dois ciclos olímpicos (2015-2016; 2019-2020) dos 20 primeiros atletas ranqueados por divisão de peso (ranking mundial: 30/05/2016; 16/03/2020). Assim, foram analisados 1.332 combates femininos (666/ciclo olímpico: <48kg=132; <52kg=72; <57kg=109; <63kg=96; <70kg=69; <78kg=106; >78kg=82) e 1.380 combates masculinos (690/ciclo olímpico: <60kg=123; <66kg=91; <73kg=100; <81kg=102; <90kg=94; <100kg=89; >100kg=91), que ocorreram antes da interrupção devido à pandemia COVID-19. Uma expert em judô utilizou um Software validado (Frami[®], BRA) para as análises temporais no judô. A fiabilidade (com teste/reteste após uma semana) obteve concordância “excelente” (CCI=0,95-0,99) em ocorrência e tempo das fases de combate (aproximação, pegada, ataque, defesa, combate de solo e pausa). Um estudo inicial com 680 combates masculinos foi realizado para consolidar os procedimentos de análise. Posteriormente, foi realizada a coleta e análise dos dados. **Resultados:** Comparado com o ciclo 2016, os combates masculinos do ciclo 2020 ($p<0,05$): duraram menos (2020=206,9 vs. 2016=240,3 segundos); tiveram maior ocorrência (2020=27% vs. 2016=6%); e tempo (2020=95,1 vs. 2016=77,6 segundos) de *Golden Score* (GS); duraram menos nas fases de pegada, ataque, defesa e solo, e mais na pausa; tiveram menor relação esforço-pausa (2020=2,3:1 vs. 2016=3,1:1). Analisando os combates masculinos por divisão de peso e comparando os dois ciclos ($p<0,05$): todas as divisões de peso reduziram o tempo de pegada em combates de Tempo Regular (TR); <60kg, <66kg, <81kg e <100kg reduziram o tempo em quase todas as fases do combate [exceto: aproximação (<66kg) e pausa (<66kg, <81kg, <100kg)]; <66kg reduziu o tempo de combates de GS. Comparado com o ciclo 2016, os combates femininos do ciclo 2020 ($p<0,05$): gastaram menos tempo nas fases de ataque, defesa e solo; reduziram o tempo em combates terminados no TR e em suas fases do combate (2020=155,3 vs. 2016=191,9 segundos); tiveram maior ocorrência (2020=20% vs. 2016=9%) e tempo gasto no GS (2020=122,1 vs. 2016=89,8 segundos), nos quais as fases de aproximação e pegada foram mais longas. Analisando os combates femininos por divisão de peso e comparando com 2016, no ciclo 2020 observou-se que ($p<0,05$): <48kg, <63kg, <70kg

e <78kg reduziram o tempo gasto em quase todas as fases dos combates que terminaram no TR [exceto: aproximação (<78kg), pegada (<48kg e <63kg) e solo (<70kg)]; houve aumento na ocorrência de GS nas categorias <48kg (↑18%), <63kg (↑17%) e <78kg (↑21%); houve menor variação na relação esforço-pausa (2020= 2,8:1 a 3:1 vs. 2016= 2,5:1 a 3,4:1). **Conclusão:** Diante das mudanças do comportamento temporal dos combates entre os ciclos olímpicos, sugere-se que treinadores de judô planejem estratégias técnico-táticas específicas de acordo com a regra vigente e as demandas temporais de esforço individuais.

Palavras-chave: Artes marciais. Esportes de combate. Análise tempo-movimento. Comportamento competitivo. Desempenho atlético.

ABSTRACT

Introduction: This research verified the impacts of judo rule changes from 2016 and 2020 Olympic cycles on the total time, temporal phases and effort:pause ratio in international combats, considering the seven weight divisions in both sexes. Three review articles (one narrative; two systematics with meta-analysis) were produced to understand the evolution of the rules and temporal structure of judo combats. **Methods:** 2,712 videos of international judo combats from two Olympic cycles (2015-2016; 2019-2020) of the top 20 athletes ranked by weight division (world ranking: 05/30/2016; 03/16/2020) were analyzed. Thus, 1,332 female combats (666/Olympic cycle: <48kg=132; <52kg=72; <57kg=109; <63kg=96; <70kg=69; <78kg=106; >78kg=82) and 1,380 male combats (690/Olympic cycle: <60kg=123; <66kg=91; <73kg=100; <81kg=102; <90kg=94; <100kg=89; >100kg=91) were analyzed, and all combats took place before the interruption due to the COVID-19 pandemic. A judo expert used a validated software (Frami[®], BRA) for temporal analysis in judo. The reliability (test/retest after one week) obtained “excellent” agreement (ICC=0.95-0.99) in the occurrence and time spent in the combat phases (approach, gripping, attack, defense, groundwork and pause). An initial study with 680 male combats was carried out to consolidate the analysis procedures. After that, data collection and analysis were performed. **Results:** Compared to the 2016 cycle, the male combats from 2020 cycle ($p<0.05$): lasted less (2020=206.9 vs. 2016=240.3 seconds); had a higher occurrence (2020=27% vs. 2016=6%) and time (2020=95.1 vs. 2016=77.6 seconds) of Golden Score (GS); lasted less in the gripping, attack, defense and ground phases, and longer in the pause; had a lower effort:pause ratio (2020=2.3:1 vs. 2016=3.1:1). Analyzing male combats by weight division and comparing the two cycles ($p<0.05$): all weight divisions reduced the gripping time in Regular Time combats (RT); <60kg, <66kg, <81kg and <100kg reduced time in almost all combat phases [except: approach (<66kg) and pause (<66kg, <81kg, <100kg)]; <66kg reduced GS combat time. Compared to the 2016, the female combats from 2020 ($p<0.05$): spent less time in the attack, defense and groundwork phases; reduced the time in combats ended in RT and in its combat phases (2020=155.3 vs. 2016=191.9 seconds); had a higher occurrence (2020=20% vs. 2016=9%) and time spent in the GS (2020=122.1 vs. 2016=89.8 seconds), in which the approach and gripping phases were longer. Analyzing the female combats by weight division and comparing with the 2016 cycle, in 2020 cycle it was observed that ($p<0.05$): <48kg, <63kg, <70kg and <78kg reduced the time spent in almost all phases of the combats which ended in RT [except: approach (<78kg), gripping (<48kg and <63kg) and groundwork

(<70kg)]; there was an increase in the GS occurrence in the <48kg (↑18%), <63kg (↑17%) and <78kg (↑21%) categories; there was less variation in the effort:pause ratio (2020= 2.8:1 to 3:1 vs. 2016= 2.5:1 to 3.4:1). **Conclusion:** In view of the changes in the temporal behavior of combats between the Olympic cycles, it is suggested that judo coaches plan specific technical-tactical strategies according to the current rule and the individual temporal demands of effort.

Keywords: Martial arts. Combat sports. Time-motion analysis. Competitive behavior. Athletic performance.

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1 INTRODUÇÃO

As regras do judô foram revisadas pela *International Judo Federation* (IJF) muitas vezes ao longo da última década (INTERNATIONAL JUDO FEDERATION, 2009, 2013, 2015, 2017a, 2017b, 2020). Mudanças significativas ocorreram na competição judô, como: alterações no formato da arbitragem (INTERNATIONAL JUDO FEDERATION, 2009, 2013); inserção do vídeo replay para minimizar erros de julgamento dos árbitros, padronização da vestimenta dos treinadores, proibição de ataques agarrando abaixo a faixa (INTERNATIONAL JUDO FEDERATION, 2009); padronização do uniforme de competição (*judogi*) (INTERNATIONAL JUDO FEDERATION, 2015, 2020); redução do tempo regular de combate (INTERNATIONAL JUDO FEDERATION, 2015, 2017a); exclusão de pontuações (INTERNATIONAL JUDO FEDERATION, 2009, 2017a); mudanças no dia da pesagem (INTERNATIONAL JUDO FEDERATION, 2009, 2013, 2015); e regras que preservam o uso de técnicas tradicionais e incentivam o judô positivo (INTERNATIONAL JUDO FEDERATION, 2009, 2013, 2015, 2017a, 2017b, 2020).

O judô, que foi criado no Japão em 1882 (BAPTISTA, 1999), teve suas primeiras regras para competição divulgadas internacionalmente pela *Kodokan* em 1950, porém, só em 1967 houve a aprovação das regras pela IJF (CALLEJA, 1988; FRANCHINI; DEL VECCHIO, 2007). Ao longo dos anos, essas normas sofreram muitas modificações no intuito de tornar as lutas atrativas ao público em geral e, nos últimos anos, para se adequar às demandas comerciais e televisivas (CAVALCANTI, 2016; FRANCHINI; DEL VECCHIO, 2007).

A rápida propagação do judô pelo mundo suscitou a necessidade de um desenvolvimento organizacional (FRANCHINI; DEL VECCHIO, 2007). Desse modo, em 1951 foi fundada a IJF, acontecimento determinante para o processo de globalização e esportivização do esporte (FRANCHINI; DEL VECCHIO, 2007). Na sequência, o judô participou da primeira Olimpíada como demonstração em 1964, e se consolidou como esporte olímpico em 1972 para homens e em 1992 para mulheres, com sete categorias de peso em cada sexo (PAIVA, 2015). Atualmente, 207 federações estão associadas à IJF (INTERNATIONAL JUDO FEDERATION, 2022). Em 1974, as alterações das regras impulsionaram a difusão do judô no mundo, dentre elas: padronizações dos gestos e vozes de comando dos árbitros; uso de placar para que o público pudesse acompanhar a luta; as interrupções deixaram de fazer parte do tempo regulamentar e a introdução das punições por meio da regra da não-combatividade (CALLEJA, 1988; FRANCHINI; DEL VECCHIO,

2007). Em 1997 ocorreu a aprovação pela IJF da utilização do *judogi* azul, novidade polêmica que suscitou discussões sobre a temática tradição versus modernidade (FRANCHINI; DEL VECCHIO, 2007).

Em 2001 houve a criação do *Golden Score* com tempo limite de 3 minutos, com o intuito de reduzir a decisão por parte dos árbitros em caso de empate, minimizando conflitos de interpretação subjetiva e, ao mesmo tempo, aumentando a tensão e atenção do espectador (FRANCHINI; DEL VECCHIO, 2007). Em 2009 ocorreu outra impactante mudança, a proibição de golpes atacando as pernas com as mãos (INTERNATIONAL JUDO FEDERATION, 2009), alteração que foi resultado de discussões sobre o uso de técnicas do judô tradicional versus golpes oriundos de outros tipos de luta (KOPTEV *et al.*, 2017). Além desta, outras modificações importantes naquele ano incluíram extinção da pontuação *koka*, inclusão da punição imediata por falso ataque e proibição de pegadas unilaterais (CAVALCANTI, 2016; INTERNATIONAL JUDO FEDERATION, 2009; KOPTEV *et al.*, 2017). Ainda em 2009 foi criado o ranking mundial pela IJF, possibilitando a avaliação de critérios sistemáticos para comparar atletas, e tornando-se em um dos principais instrumentos de classificação para os Jogos Olímpicos (FRANCHINI; JULIO, 2015; INTERNATIONAL JUDO FEDERATION, 2019).

Nos anos subsequentes, a preocupação em tornar o judô mais ativo e televisivo tornou-se ainda mais evidente nas regras. Em 2013 o tempo de imobilização para obter *Ippon* reduziu de 25 para 20 segundos, as penalidades deixaram de resultar em pontuações para o adversário, foi inserido a supervisão da luta pelos árbitros por meio da reprodução do vídeo em câmera lenta e o tempo limite do *Golden Score* foi abolido (passa a ter tempo indeterminado) (CAVALCANTI, 2016; CEYLAN; BALCI, 2017; CONFEDERAÇÃO BRASILEIRA DE JUDÔ, 2014; INTERNATIONAL JUDO FEDERATION, 2013). Em 2015 houve redução do tempo de luta do feminino de 5 para 4 minutos (INTERNATIONAL JUDO FEDERATION, 2015). Em 2017, reduziu o tempo de luta do masculino de 5 para 4 minutos, houve exclusão da pontuação *Yuko* e redução do número de *Shidos* de 4 para 3, que não decidia mais o vencedor no fim do tempo regular (CEYLAN; BALCI, 2017; CONFEDERAÇÃO BRASILEIRA DE JUDÔ, 2017; INTERNATIONAL JUDO FEDERATION, 2017a). Em 2018, acúmulo de *Shido* também não decidia mais o vencedor no *Golden Score* (CONFEDERAÇÃO BRASILEIRA DE JUDÔ, 2018; INTERNATIONAL JUDO FEDERATION, 2017b).

Essas inúmeras alterações da regra durante os anos transformaram as características de esforço-pausa realizadas pelo atleta, que por sua vez precisou se adaptar técnica e taticamente

para atender às novas demandas (BARRETO et. al., 2019; BRITO, MOREIRA et. al., 2017; CIRINO, 2016; MIARKA, 2014). Nesse contexto, a contribuição de conhecimentos científicos na sistematização do treinamento dos atletas tornou-se essencial na produção de altos padrões de desempenho (FRANCHINI, 2001; FRANCHINI; DEL VECCHIO, 2007). Assim, aplicações da metodologia do treinamento desportivo, biomecânica, fisiologia do exercício, avaliação física, dentre outros, possibilitaram direcionamentos para elaboração de estratégias e melhora da especificidade dos treinos (DAL BELLO *et al.*, 2019; FRANCHINI, 2001; MARQUES *et al.*, 2008).

Nos últimos anos, várias pesquisas têm investigado as relações esforço-pausa, as ações motoras e interações técnico-táticas executadas para se obter a vitória (BARRETO et. al., 2019; BRITO, MIARKA et. al., 2017; BRITO, MOREIRA et. al., 2017; CIRINO, 2016; DAL BELLO et. al., 2019; MIARKA, 2014, MIARKA et. al., 2012). Para tanto, a análise observacional de vídeos de luta tem sido uma metodologia muito utilizada, pois permite a descrição do que está ocorrendo de forma quantitativa e qualitativa, cumprindo critérios de validade e fiabilidade, com o objetivo de detectar variáveis que afetam o desempenho esportivo (IZQUIERDO, 2008; MIARKA et. al., 2011). Nestas pesquisas, foram realizadas avaliações técnico-táticas a partir de modelos temporais nas diferentes categorias de peso e sexo, procurando identificar quais comportamentos estão associados aos atletas vencedores (BARRETO et. al., 2019; BRITO, MIARKA et. al., 2017; BRITO, MOREIRA et. al., 2017; CIRINO, 2016; DAL BELLO et. al., 2019; MIARKA, 2014, MIARKA et. al., 2012). Entretanto, ainda é escasso o número de estudos que abordam o efeito das modificações das regras dos últimos ciclos olímpicos em cada uma das sete divisões de peso em cada categoria de sexo.

Tal problemática torna-se importante pois, atualmente, são observados treinos competitivamente descontextualizados em que atletas do sexo feminino e masculino, leves e pesados, praticam o mesmo treinamento, inclusive durante os diferentes ciclos olímpicos. Segundo Oleg *et al.* (2018) no judô muitos métodos e meios de treinamento para competição precisam de mudanças qualitativas para se tornarem eficazes. Desse modo, aparentemente, o treinador não tem levado em consideração a influência que as mudanças nas regras e as características do atleta podem afetar as demandas temporais e de relação esforço-pausa dos combates de judô. Nesse sentido, a realização desse estudo se justifica por fornecer informações sobre quais são as demandas temporais das ações realizadas por atletas de judô masculino e feminino de diferentes pesos e em ciclos Olímpicos distintos que tiveram importantes alterações da regra. Esse conhecimento permite a compreensão sobre como a

regra influencia as necessidades energéticas de homens e mulheres de pesos diferentes quando se pretende obter resultados competitivos no judô, permitindo que o treinador planeje estratégias técnico-táticas específicas para cada divisão de peso e sexo.

OBJETIVOS

A seguir serão apresentados o objetivo geral e os objetivos específicos deste estudo.

1.1.1 Objetivo geral

Verificar o impacto das modificações das regras do judô dos ciclos Olímpicos 2016 e 2020 sobre as fases temporais de combates internacionais.

1.1.1.1 Objetivos específicos

Comparar por divisão de peso de judô considerando o momento de término do combate, nas categorias masculina e feminina, as seguintes variáveis:

- a) Tempo total de combate entre os ciclos Olímpicos 2016 e 2020;
- b) Fases temporais dos combates entre os ciclos Olímpicos 2016 e 2020;
- c) Relação esforço-pausa dos combates em cada ciclo olímpico.

2 REVISÃO DE LITERATURA

O capítulo revisão de literatura conta com a apresentação de 3 artigos [1 revisão narrativa (BARRETO *et al.*, 2022a) e 2 revisões sistemáticas e metanálise (BARRETO *et al.*, 2022b)]. Os artigos focam nos seguintes pontos de análise do judô:

- a) A evolução das regras do judô ao longo dos últimos anos: artigo de revisão narrativa publicado na *Revista de Artes Marciais Asiáticas* sob o título *Judo combat time, scores, and penalties: Review of competition rules changes between 2010 and 2020* (BARRETO *et al.*, 2022a);
- b) Análise temporal de combates de judô masculino de nível internacional ao longo dos últimos anos: artigo de revisão sistemática e metanálise publicado na revista *Frontiers in Psychology* sob o título *Combat time in international male judo competitions: A systematic review and meta-analysis* (BARRETO *et al.*, 2022b);
- c) Análise temporal de combates de judô feminino de nível internacional ao longo dos últimos anos: artigo de revisão sistemática e metanálise que foi aceito pela revista *Ido Movment for Culture* sob o título *Combat time in international female judo competitions: A systematic review and meta-analysis* e ainda será publicado.

Considera-se que a compreensão dessas temáticas é crucial para a realização desse estudo, já que o mesmo tem o intuito de verificar como as recentes modificações das regras do judô impactam as características tempo-movimento dos combates por categorias de sexo e peso. Para respeitar o direito de uso e reprodução dos artigos publicados nas revistas científicas foram disponibilizados nas páginas seguintes apenas os resumos dos artigos publicados (Figuras 1 e 2). O terceiro artigo que ainda será publicado, pode ser encontrado na íntegra no subcapítulo 2.3. Os textos dos artigos estão em inglês por se tratar de publicação internacional e a formatação segue as normas de suas respectivas revistas. Os artigos publicados (BARRETO *et al.*, 2022a, 2022b) podem ser encontrado nos seguintes links:

<http://revpubli.unileon.es/ojs/index.php/artesmarciales/article/view/7122>

<https://www.frontiersin.org/articles/10.3389/fpsyg.2022.817210/full>






Além disso, deve-se ressaltar que esta tese de doutorado foi financiada em parte pela Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Código Financeiro 001, bolsa de doutorado sanduíche PDSE/CAPES, concessão nº 88881.622965/2021-1, e que não há conflito de interesse.

2.1 A EVOLUÇÃO DAS REGRAS DO JUDÔ AO LONGO DOS ÚLTIMOS ANOS

Figura 1 - Evolução das regras do judô ao longo dos últimos anos



Judo combat time, scores, and penalties: Review of competition rules changes between 2010 and 2020

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ORIGINAL PAPER

Abstract

This study aimed to describe and analyze the main changes in the official competitive rules of judo between 2010 and 2020, highlighting changes in combat time, scores and penalties. In this retrospective study, a search was performed for official documents which regulated judo rules between 2010 and 2020 on the websites of the International Judo Federation and the Brazilian Judo Confederation, as well as refereeing manuals of the Sergipe Judo Federation (Brazil) and on the Google platform. Over the years, regular combat time has been shortened (2015=5'→4' for women; 2017=5'→4' for men), as well as *osaekomi* time (2013=25"→20"). This change was intended to facilitate the public's understanding of judo scores, as well as to devalue the use of penalties to achieve the victory (2010=*koka*'s exclusion; 2013=penalty was no longer worth scores; 2017=*yuko*'s exclusion, *shido* no longer decided the winner in regular time; 2018=*shido* no longer decided the golden score winner). Attack actions were encouraged (ban on actions to flee combat) and there was an intention to reduce the risk of injuries in competitive judo (prohibition of some types of actions and grips). In other words, there was an attempt by the International Judo Federation to encourage positive judo through the rules from 2010 to 2020. However, these constant rule changes made the competitive training context unstable. Judo coaches and athletes must be aware at the end of each Olympic cycle for new changes which will eventually be introduced and adapt to them quickly to achieve high performance.

Keywords: Martial arts; combat sports; judo; performance analysis; referee; rules; competition.

Fonte: BARRETO *et al.* (2022a).

2.2 ANÁLISE TEMPORAL DE COMBATES DE JUDÔ MASCULINO DE NÍVEL INTERNACIONAL AO LONGO DOS ÚLTIMOS ANOS

Figura 2 - Análise temporal de combates de judô masculino de nível internacional ao longo dos últimos anos.



Combat Time in International Male Judo Competitions: A Systematic Review and Meta-Analysis

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This study aimed to synthesize literature data on male judo combat time in international competitions between 2010 and 2019. The search was carried out from May 8th to June 11th, 2021, in electronic databases using the following keywords: (“technical-tactical” OR “time motion” OR “combat time”) AND (“judo” OR “combat sports” OR “martial arts”). After the selection process, 8 articles were included in the systematic review and 7 in the meta-analysis. These studies analyzed 2,562 international male judo combats over the years 2010–2019. We observed that the average male judo combat time changed (2010 = 202.8; 2011–2012 = 304.8; 2016 = 237.4; 2018–2019 = 189.8 s) after each rule change (2010, 2013, 2017, and 2018). There was a significant difference between combats that ended up to the regular time and those that needed overtime (Golden Score: 2013 = 3% vs. 2018–2019 = 21%; $p = 0.03$). There were differences between 60 kg ($p \leq 0.019$) and + 100 kg ($p \leq 0.04$) categories and the others in 2011–2012. However, no significant difference was found between the combat time by weight division after the 2017 rule changes, although there are still differences in relation to the end of the combats ($p < 0.001$). There were significant changes in the male judo combat time with each rule change (2010, 2013, 2017, and 2018), and the data from the included studies point to a trend of homogeneity in the combat time spent between the weight divisions over the years, and an increase in the occurrence of Golden Score. More studies need to be carried out to identify the new temporal behaviors of athletes.

Keywords: time-motion studies, martial arts, athletic performance, psychomotor performance, task performance and analysis

2.3 ANÁLISE TEMPORAL DE COMBATES DE JUDÔ FEMININO DE NÍVEL INTERNACIONAL AO LONGO DOS ÚLTIMOS ANOS

Esse artigo ainda está em processo de publicação na revista *Ido Movement for Culture*.

Article

Combat Time in International Female Judo: A Systematic Review and Meta-Analysis

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Abstract: This study analyzed data on combat time in international female judo between 2010-2019 by weight division. The following descriptors were searched in electronic databases (May 8 to June 11, 2021): (“technical-tactical” OR “time motion” OR “combat time”) AND (“judo” OR “combat sports” OR “martial arts”). 793 articles were found, after the screening process 6 were included in the systematic review and 5 in the meta-analysis. A total of 1,485 combats were analyzed. The following information was extracted: mean and standard deviation of total combat time; frequency of combats finished in Regular time (RT) or Golden Score (GS); total combat time by weight division. The combat time changed at each rule change and the 2012 year had the highest combat time (2012=260.9 seconds). The GS occurrence increased in 2018-2019 compared to 2013 (GS: 2013=4.4%; 2018-2019=18%; Z=2.87; p=0.004). The +78kg category had the highest GS occurrence in 2013 (16.7%) among all divisions, however 5 out of 6 combats ended before RT in 2018-2019. The 48kg category maintained a low GS occurrence over the years. Combat times changed in the 2010-2019 period, with a trend towards homogeneity by weight divisions in 2018-2019. However, the GS occurrence has increased over the years.

Key words: martial arts; combat sports; Golden Score; performance; competition; rules.

1. Introduction

The history of female judo competitions begins in the late 1960s and 1970s when women participated in official competitions in some countries [1,2]. Female combat time nowadays is 4 minutes, and the extra time (Golden Score, if necessary) is unlimited; however, these combat times have varied over the years according to the rules in force at the time [3,4,5,6]. The regular combat time in 2010 was 5 minutes, and rule changes reduced the Golden Score time from 5 to 3 minutes [4]. Then, the Golden Score time became unlimited in 2013 [5]. New rule changes in 2015 established that the normal combat time for women would be reduced from 5 to 4 minutes [6]. In this sense, it is believed that combat structures and dynamics have also varied over the years. Therefore, judo coaches need to choose good strategies to adapt athletes as quickly as possible to the new rules, aiming at the technical-tactical structuring of the global dynamics of combat.

Therefore, several authors have studied female judo combat based on an analysis of the temporal structure and technical-tactical movement, including total combat time, standing combat, non-contact displacement, gripping, groundwork, pause time, scores, penalties, number of techniques and attack efficiency index [7,8,9]. These technical-tactical variables and rule changes might directly impact the physical, technical and tactical preparation of female athletes.

Systematic reviews and meta-analyses of judo make it possible to group data from primary researchers on a variable and explore its effects in specific groups. These studies are then used in performance analysis research to support decision-making in effectively prescribing a judo training model from evidence-based guidelines [10,11,12]. Therefore, identifying how female judo combat time behaves as a result of rule changes through a systematic review and meta-analysis could help to predict temporal actions and assist in the training prescription. Thus, this study aims to analyze data from the literature on the combat time of female judo in international competitions over the years and by weight division. We believe that combat times have changed over the years due to constant changes in the rules, and that this information can help coaches plan competition-specific training for each weight division.

2. Methods

2.1. *Experimental Approach to the Problem*

Cross-sectional observational studies which contained data on total combat time (in seconds or minutes) of women's judo at the international level were used in this systematic review and meta-analysis. Studies that presented the total combat time separated by weight division [extra-lightweight (48kg), half-lightweight (52kg), lightweight (57kg), half-middleweight (63kg), middleweight (70kg), half-heavyweight (78kg) and heavyweight (+78kg)] were used in a secondary analysis.

The following were considered as inclusion criteria for the review: a) articles published in peer-reviewed journals; b) studies written in Portuguese, English or Spanish. As this research topic is recent, there was no limitation on the deadline for publication of articles. Exclusion criteria were: a) studies regarding sports other than judo; b) articles that analyzed simulated combats; c) studies whose combats were not from international level competitions; d) articles whose sample consisted of adolescent athletes or just men; and e) articles which did not contain the combat time.

2.2. *Included Studies*

The following descriptors were searched in electronic databases: ("technical-tactical" OR "time motion" OR "combat time") AND ("judo" OR "combat sports" OR "martial arts"). This search was carried out from May 8 to June 11, 2021 in the following electronic databases: SciELO, PubMed, BVS - virtual health library (in LILACS, Medline and IBECs databases), EBSCOhost (in the databases of Sportdiscus, CINAHL and Medline).

The Excel 2013 program (Microsoft, Washington, USA) was used to extract the references from the databases. Two reviewers conducted the article search and selection process independently. A third author evaluated the study when there was disagreement among authors regarding the inclusion or not of studies. The Preferred Report Items for Systematic Reviews and Meta-Analyses

(PRISMA) were used in the screening process of collected articles [13]. This article selection process is described in the PRISMA flowchart (Figure 1).

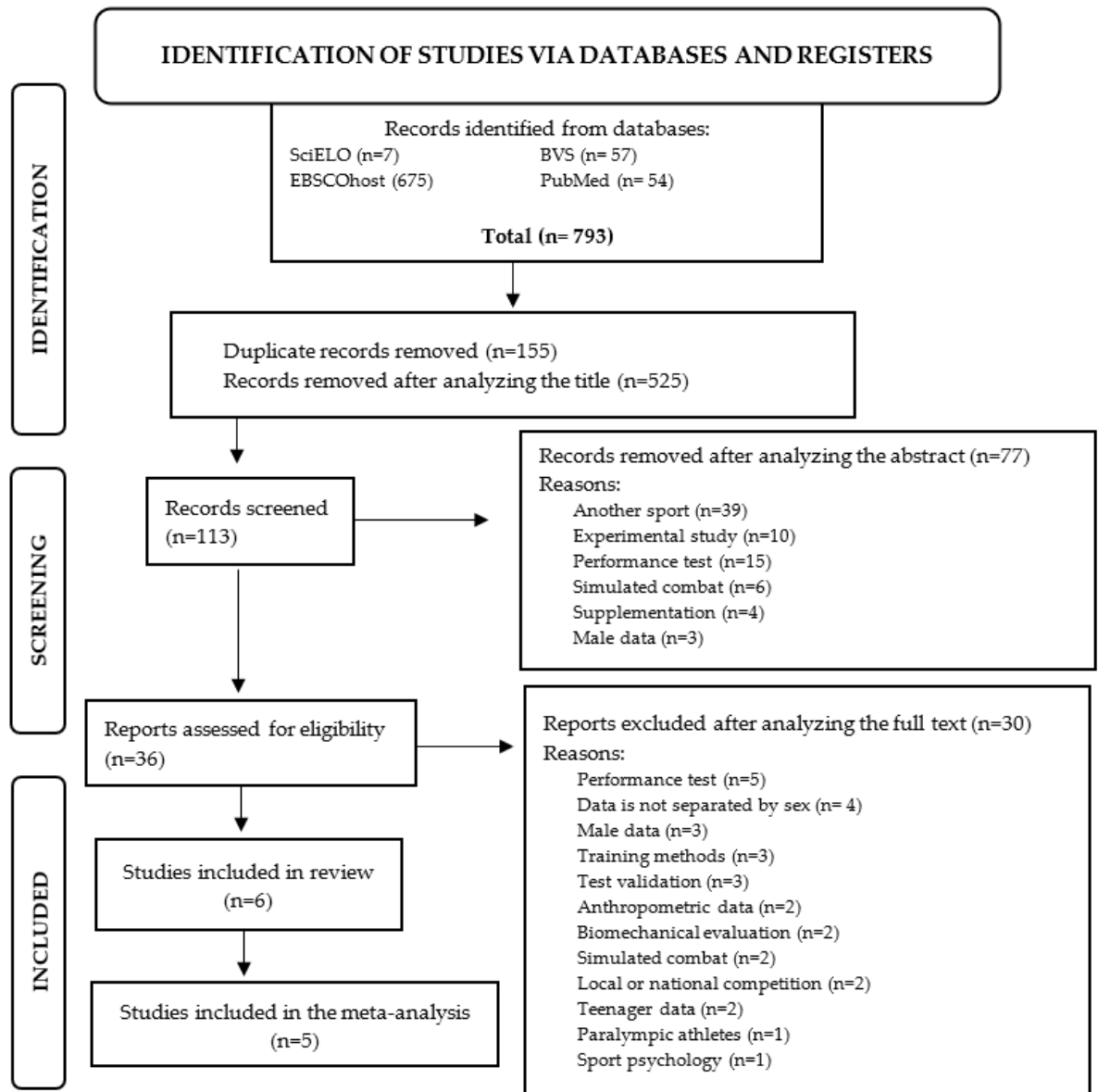


Fig. 1. PRISMA flow diagram of study selection.

The search in the databases with the keywords resulted in 793 articles, of which 155 duplicate articles were manually removed. Next, 525 articles were excluded by reading the title, as it was clear that they analyzed other combat sports or male judo. Of the 113 remaining articles, 77 were excluded after reading the abstract for the following reasons: a) analysis of other sports; b) experimental studies; c) analysis of performance tests, d) simulated combat or nutritional supplementation; and e) studies in male judo. Thus, 36 articles remained for full reading, review and eligibility assessment for this systematic review and meta-analysis. After evaluation, 30 articles were excluded for the following reasons: performance testing studies; analysis of data not separated by sex or only with male athletes; studies on training methods, test validation, anthropometric data or biomechanical assessment; analysis of combat simulations, local or national competitions; samples with adolescents or Paralympic athletes; and studies in sports psychology. Finally, 6 studies were included in the systematic review; however, only 5 studies were part of the meta-analysis, as one of them did not present all of the data needed for the analysis (Fig. 1).

2.3. Procedures

The RoBANS tool, which was validated to analyze non-randomized studies [14], was used to assess the quality of the 6 studies included in the systematic review. This risk of bias assessment tool analyzes 6 items, which should be classified as low, high or unclear risk[14]. Study analysis was performed by two reviewers independently; divergences from these analyses were resolved by consensus with a third reviewer. At least two authors performed the extraction of qualitative and quantitative data independently and entered them into the Excel 2013 program (Microsoft, Washington, USA).

The following information was extracted from the studies for qualitative analysis and presented in table form: a) author and year; b) year of competition; c) type of competition evaluated; d) level of athletes; e) combat time; f) combat analysis instruments; g) analysis protocol; h) data extracted for this systematic review. The following information was extracted from the studies for the quantitative analysis and presented in Figures: a) mean and standard deviation of the total combat time in seconds; b) frequency of combats which ended in regular time or Golden Score; c) total combat time by weight division.

2.4. Statistical Analysis

Descriptive Tables, Graphs and Forest plots were applied to show the data analysis. The Revman.5 software program from the Cochrane website was used for meta-analysis considering a significance level of $p < 0.05$. For dichotomous outcomes, meta-analysis was used to verify the effect size of combats which ended in regular time vs. those which ended in Golden Score. To do so, a random effects model and the Mantel-Haenszel statistical method with the odds ratio effect measure were used. In addition, a continuous outcome meta-analysis was applied based on the inverse variance statistical method with a random effect analysis model and standard mean difference of the effect measure to verify the effect size between weight division. Cochran's Q test and I^2 statistic were used to assess the heterogeneity between the included studies, being classified as: may not be important (0-29%), may represent moderate (30-49%), substantial (50-74 %), or considerable (75-100%) heterogeneity [15].

3. Results

3.1. Description of studies

There were 6 studies which met the eligibility criteria in this systematic review [16,17,18,19,20,12]. The qualitative analysis of articles is shown in Table 1. Only data referring to the female combat time were extracted from the studies for this systematic review, although they presented other variables such as characteristics of combat phases, techniques used and attack effectiveness index. Thus, the data of the studies described in Table 1 only refers to the combats analyzed in this systematic review.

Table 1. Studies on time-motion analysis in female judokas in international competitions (n=1,485)

Author	Competition year	Championships	Study group for this review	Combat time sample	Instruments	Protocol	Data for this review
Adam <i>et al.</i> , 2013[16]	2012	London Olympic Games	Gold medal at the Olympic Games	32 combats 48kg n=5; 52kg n=5; 57kg n=5; 63kg n=5; 70kg n=4; 78kg n=4; >78kg n=4	Standardized audiovisual techniques and graphic markings	Time motion indicators	CT CTW
Boguszewski, 2016[17]	2016	Rio de Janeiro Olympics Games (Finals)	Gold and Silver medal at the Olympic Games	7 combats 1 by each weight division	Observational sheets in 10-second fight sequences	Kalina's method of combat dynamics measurement	CT
Ceylan & Balci, 2020[18]	2018- 2019	World Championships	Elite athletes	665 combats 48kg n=93; 52kg n=107; 57kg n=113; 63kg n=96; 70kg n=99; 78kg n=79; >78kg n=78	Data from official IJF website	Combat time	CT ECT CTW
Segedi <i>et al.</i> , 2014[19]	2013	Rijeka Grand Prix (elimination rounds)	Elite athletes	68 combats	Recorded by video camera	Combat end time and score analysis	ECT ECTW
Soriano <i>et al.</i> , 2019[20]	2010	International (different competitions)	Elite athletes	75 combats 48kg n=25; 52+57+63kg n=25; >78kg n=25	Observation tool combined with a field format category system. LINC v. 1.1	Time motion indicators	CT CTW
Sterkowics-Przybycien <i>et al.</i> , 2017[12]	2011-2012	International (different competitions)	Athletes ranked for Olympic Games	638 combats 48kg n=103; 52+57+63kg n=308; 70+78kg n=176; >78kg n=51	VirtualDub Program 1.8.6 Frami software	Combat phases	CTW

CT - Combat time; CTW - Combat time by weight division; ECT - End of combat time; ECTW - End of combat time by weight division; kg – kilograms

The judo combats analyzed by the studies covered the period between 2010 and 2019, and included the Olympic Games (2012 and 2016), the World Championship (2018 and 2019) and other international competitions such as the World Circuit, Grand Slam, Grand Prix, and others (2010 to 2013). A total of 1,485 female combats were analyzed (2010=75; 2011-2012=670; 2013=68; 2016=7; 2018-2019=665). They were gold or silver medalists in the Olympic Games[16,17], athletes classified for the Olympic Games[12], or elite athletes[18,19,20], which proves the high performance level of the combats analyzed. The instruments and protocols used to assess the combats varied (Table 1); however, the previous study[23] identified that video analysis results are stable when expert judo analysts performed video analysis in slow motion or live.

3.2. Risk of bias in included studies

The judgment of the authors of this systematic review regarding the risk of bias of the 6 included studies using the RoBANS tool is shown in Figure 2. At least 66.7% of the included articles had a low risk of bias. However, ~33% of the studies had incomplete outcome data. This is because the large number of variables collected when analyzing judo combats makes it impossible to investigate all the variables in a single article. Around 17% of the evaluated articles did not measure exposure, or they did not consider confounding variables, or they were evaluated with problems of outcome evaluation blindness. This is for the following reasons: the authors did not discuss all of the data presented; they did not report the number of combats by weight division; they did not specify characteristics of combat evaluators (judo degree, competitive experience and others); or they did not report reliability data for their analyzes and/or instruments used.

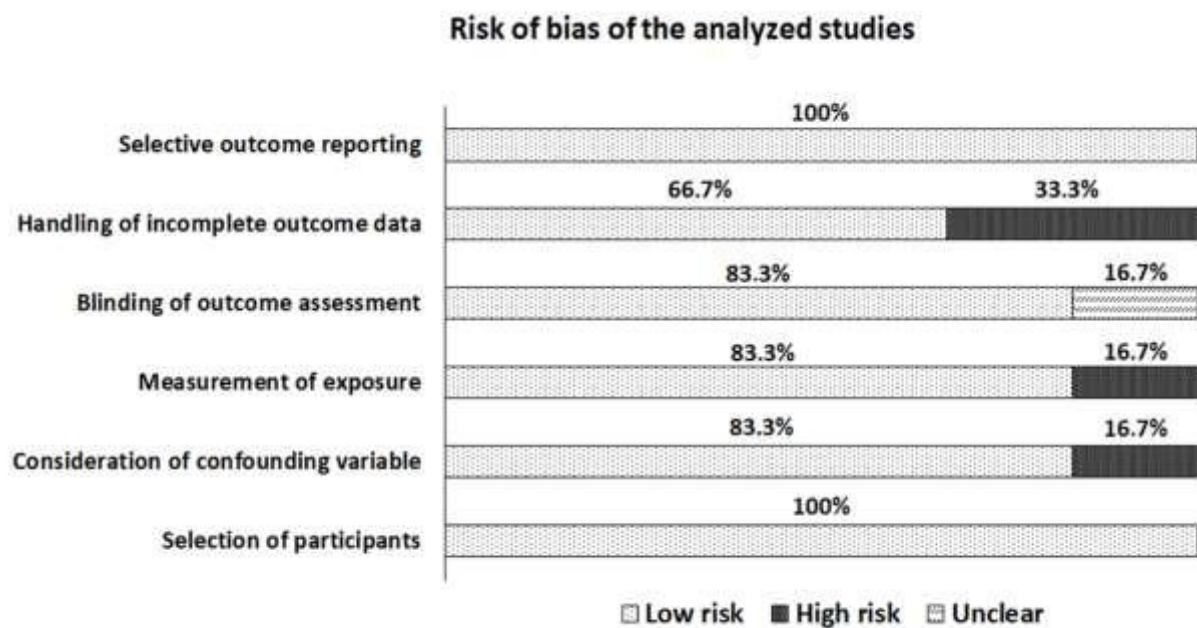


Fig. 2. Review authors' judgements about each risk of bias item across all included studies (%).

3.3. Quantitative data on female combat time

Quantitative combat time data for the studies included are presented in Table 2. The average combat time in the study by Adam *et al.* [16] was calculated by the authors of this study based on data of the duration of women's combats described in that article. The data show that female judo had an average combat time ranging from 260.9 seconds (2012) to 180.7 seconds (2018-2019). The lowest average combat time by weight division was in 2018-2019 in the 78kg division (163.9 seconds) and the longest combat time was in 2012 in the 57kg category (312.2 seconds).

Table 3 shows the moment when the combats ended according to the included studies. The data for the variable "Before regular time" from the study by Ceylan & Balci[18] was the result of the sum of combats that ended in 61-120s; 121-80s and 181-239s. The percentage by end of combat time in Table 3 was also calculated by the authors of this study. Most of the combats analyzed ended before the regular combat time in both 2013 and 2018-2019, (2013=57.4%; 2018-2019=70%). The weight division that had the most combats finished before regular time in 2013 was the 48kg category (100%); the 78kg category had more combats that ended in regular time (77.8%); and the +78kg category had more combats that ended in the Golden Score (16.7%). In 2018-2019, Ceylan & Balci[18] found a significant difference between the weight division and the time at which the combat ended ($\chi^2=2198.64$; $p<0.001$; $\text{PHI}=0.135$). Although the authors did not report the values by category, they wrote that the frequency of the Golden Score was higher in the 57kg category in 2018-2019, unlike 2013; however, the 48kg category continued to present the lowest occurrence of the Golden Score.

Table 2. Total combat time in female judo competitions over the years.

Weight division	Combat time (s) (mean±standard deviation)				Combat time (s) (median; interquartile range)
	Soriano <i>et al.</i> (2019)[20] 2010 International competitions (n=75)	Adam <i>et al.</i> (2013)[16]* 2012 Olympic Games (n=32)	Boguszewski (2016)[17] 2016 Olympic Games (n=7)	Ceylan & Balci (2020)[18] 2018- 2019 World Championships (n=665)	Sterkowics-Przybycien <i>et al.</i> (2017)[12] 2011-2012 International competitions (n=638)
All categories	197.5±92	260.9±103	232.7	180.7±113.4	---
48kg	202.2±88.8	300±0		186.4±110.5	233.1; 174.5
52kg		281±79		190.8±108.1	
57kg	189.9±96.1	312.2±19.2	---	188.6±121.5	249.7; 204.3
63kg		174.6±89.2		184.8±111.1	
70kg		246.8±169.2		170.8±107.8	
78kg	---	207.3±112.7		163.9±122.9	228.6; 192.6
+78kg	200.5±94.4	298.5±149.4		173.1±110.7	213; 160.1

* Average combat time calculated by the authors of this study based on the time data in the article; s- seconds

Table 3: Moment when combat ends in female judo competitions over the years.

Weight division	End of combat time	Segedi <i>et al.</i> (2014)[19] 2013 Grand Prix (n=68)		Ceylan & Balci (2020)[18] 2018- 2019 World Championships (n=665)	
		u	% #	U	%
All categories	Before regular time	39	57.4	465 *	70 #
	In regular time	26	38.2	80	12
	Golden Score	3	4.4	120	18
48kg	Before regular time	2	100		
	In regular time	0	0		
	Golden Score	0	0		
52kg	Before regular time	3	37.5		
	In regular time	5	62.5		
	Golden Score	0	0		
57kg	Before regular time	15	83.3		
	In regular time	3	16.7		
	Golden Score	0	0		
63kg	Before regular time	6	42.9		
	In regular time	7	50		---
	Golden Score	1	7.1		
70kg	Before regular time	7	63.6		
	In regular time	4	36.4		
	Golden Score	0	0		
78kg	Before regular time	1	11.1		
	In regular time	7	77.8		
	Golden Score	1	11.1		
+78kg	Before regular time	5	83.3		
	In regular time	0	0		
	Golden Score	1	16.7		

*Sum of the data present in the study for combats that ended in 61-120; 121-80 and 181-239s; # Percentage of combats calculated by the authors of this study; u – unit

The study by Sterkowics-Przybycien *et al.* [12] presented data as median and interquartile range (and not as mean and standard deviation), and so it was not possible to group it with other studies for quantitative analysis. Thus, only 5 included studies participated in the meta-analysis. The studies were grouped as follows for the quantitative analysis: a) total combat time over the years[16,17,18,19,20], whose distribution of combat was: 2010=75; 2012=32; 2013=68; 2016=7; 2018-

2019=665 (total = 847 combats); b) total combat time by weight division over the years[16,18,20], whose distribution of combats was: 48kg=123; 52kg=112; 57kg=118; 63kg=101; 70kg=103; 78kg=83; +78kg=107 (total=747 combats) (Table 1).

3.3.1. Total female combat time over the years

Figure 3 shows the total time in seconds of female judo combats over the years and the analysis of when combats ended in the year 2013 vs. 2018-2019. We added the number of combats from the 61-120s, 121-80s, 181-239s and 240s periods from the study by Ceylan & Balci[18] to analyze the end of the combat. We also calculated the percentage of data from the studies[18,19]. There was a significant increase of 13.6% in the occurrence of the Golden Score in 2018-2019 compared to 2013 (Z=2.87; p=0.004).

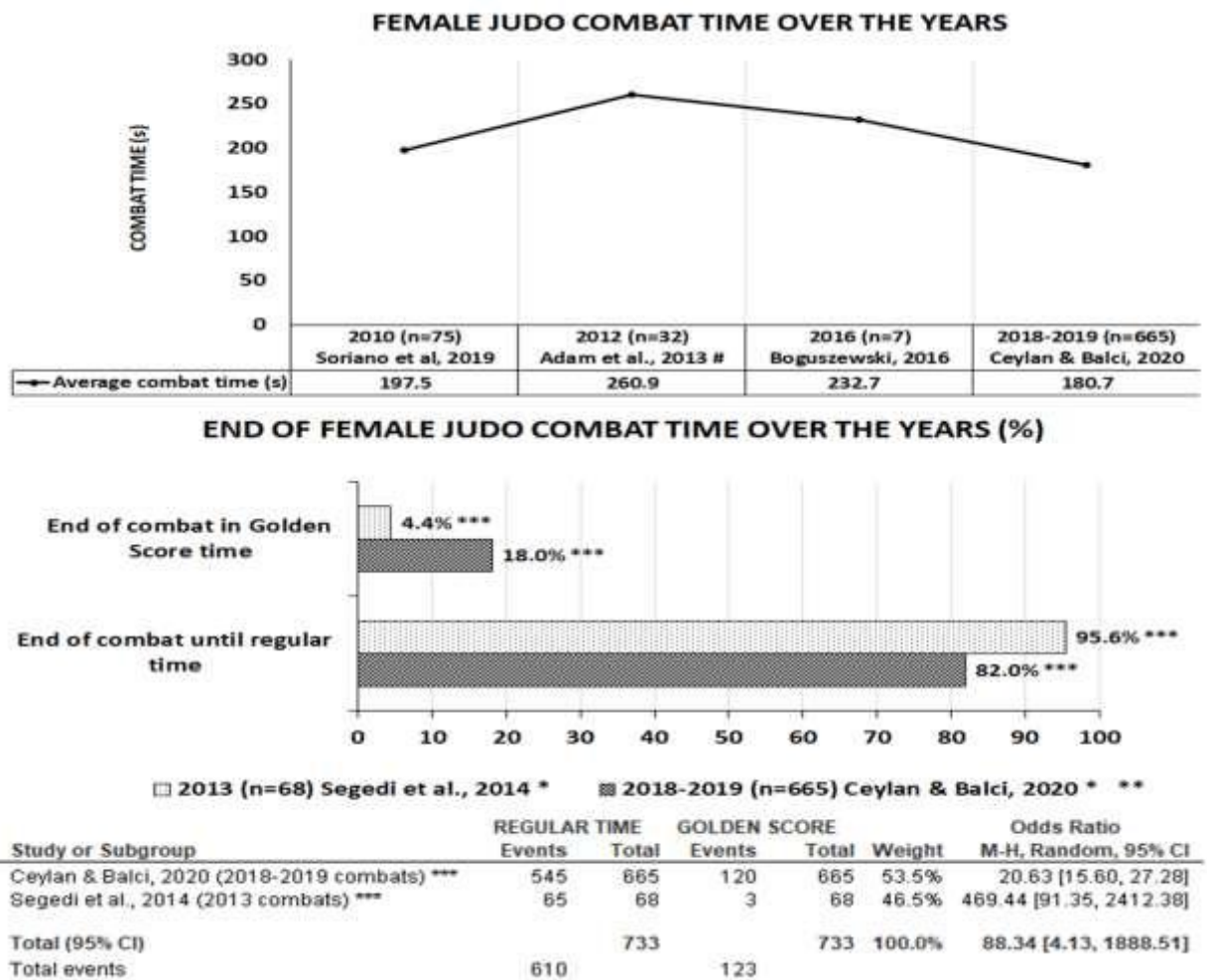


Fig. 3. Total time and moment when female judo combats ended over the years.

Average combat time calculated by the authors of this study, based on the time data in the article; * Percentage of combats calculated by the authors of this study; ** We added up the combats which ended in 61-120; 121-80; 181-239 and 240s; *** Significant difference (Z=2.87; p=0.004).

3.3.2. Total female combat time by weight division over the years

The average female combat time by weight division over the years is shown in Figure 4. The study by Sterkovics-Przybycien *et al.* [12] presents data in median and interquartile range, so it was not possible to include it in the analysis. Data from Soriano *et al.* [20] only refer to the 48kg and +78kg categories, as the authors presented the sum of the combat time for the 52, 57 and 63kg categories together, and they did not present data for the 70kg and 78kg categories. Data from Adam *et al.* [16]

were calculated from the combat times reported in their study. Data indicate that combat time has become more homogeneous over the years in the different weight divisions. The meta-analyses of combat time between weight division can be seen in Figure 5, in which no significant differences were found between the divisions over the years.

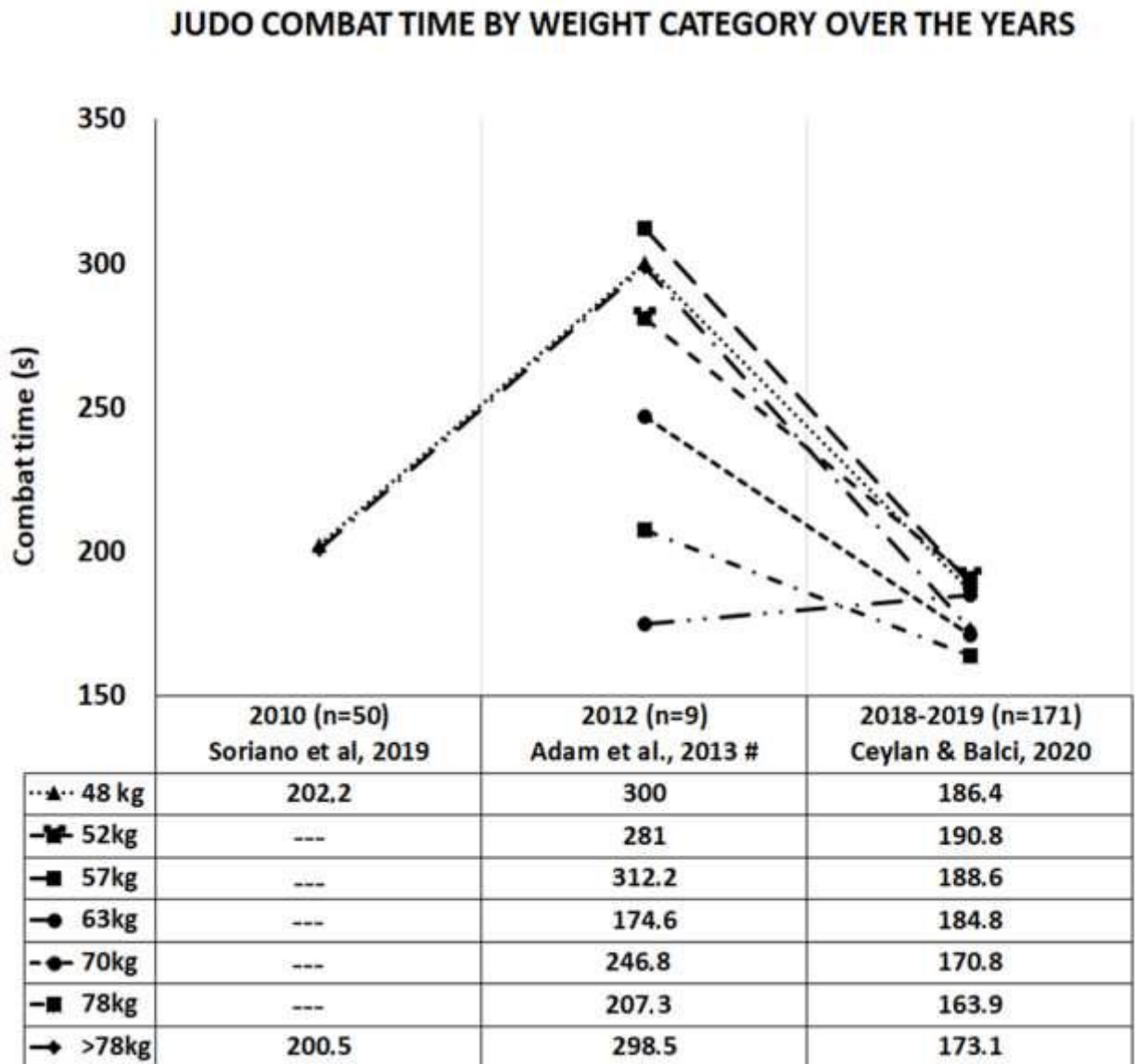
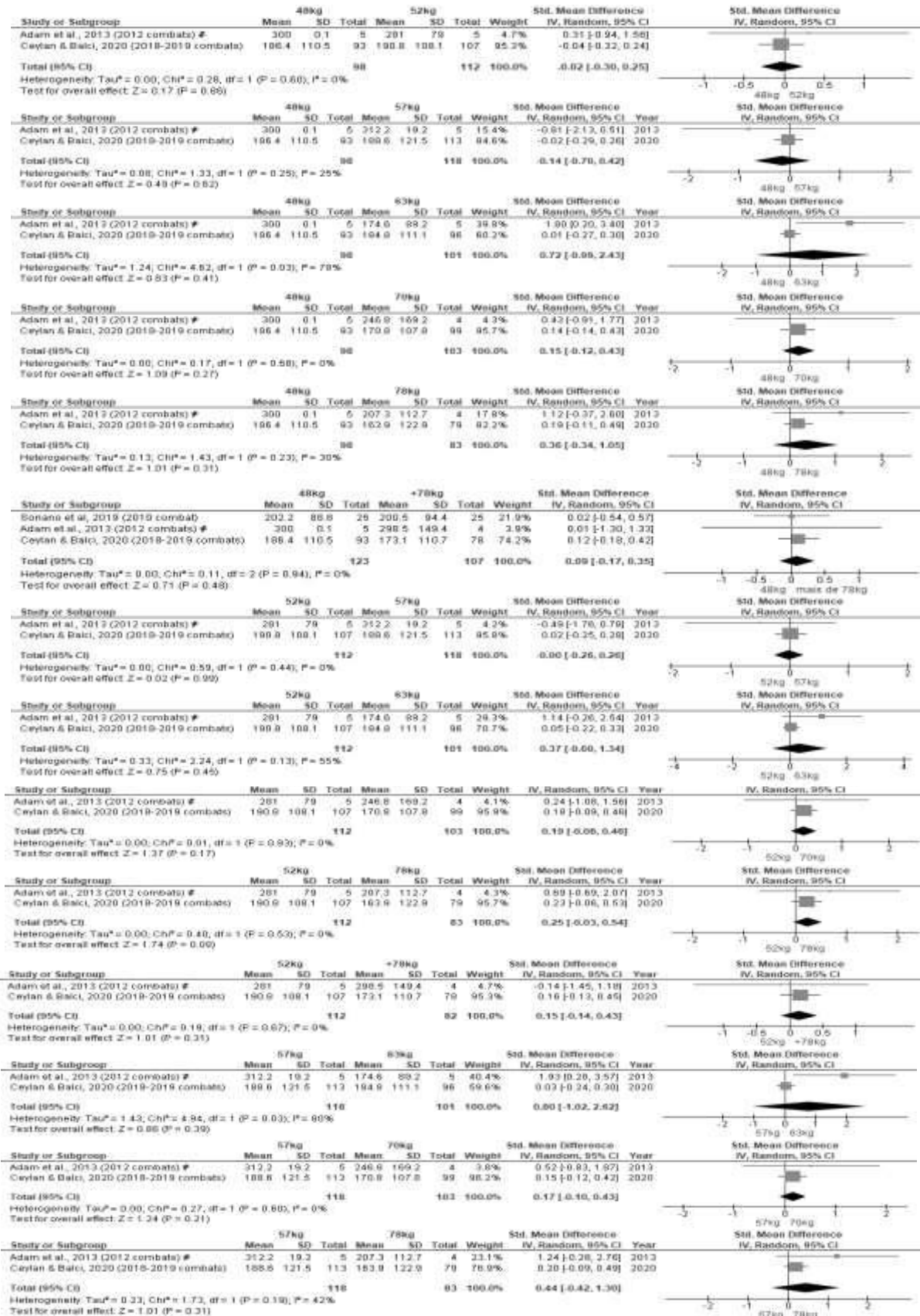


Fig. 4. Duration of combat by weight division over the years.

Average combat time by category calculated by the authors of this study.

COMPARISON OF JUDO COMBAT TIME BY WEIGHT DIVISIONS OVER THE TIME



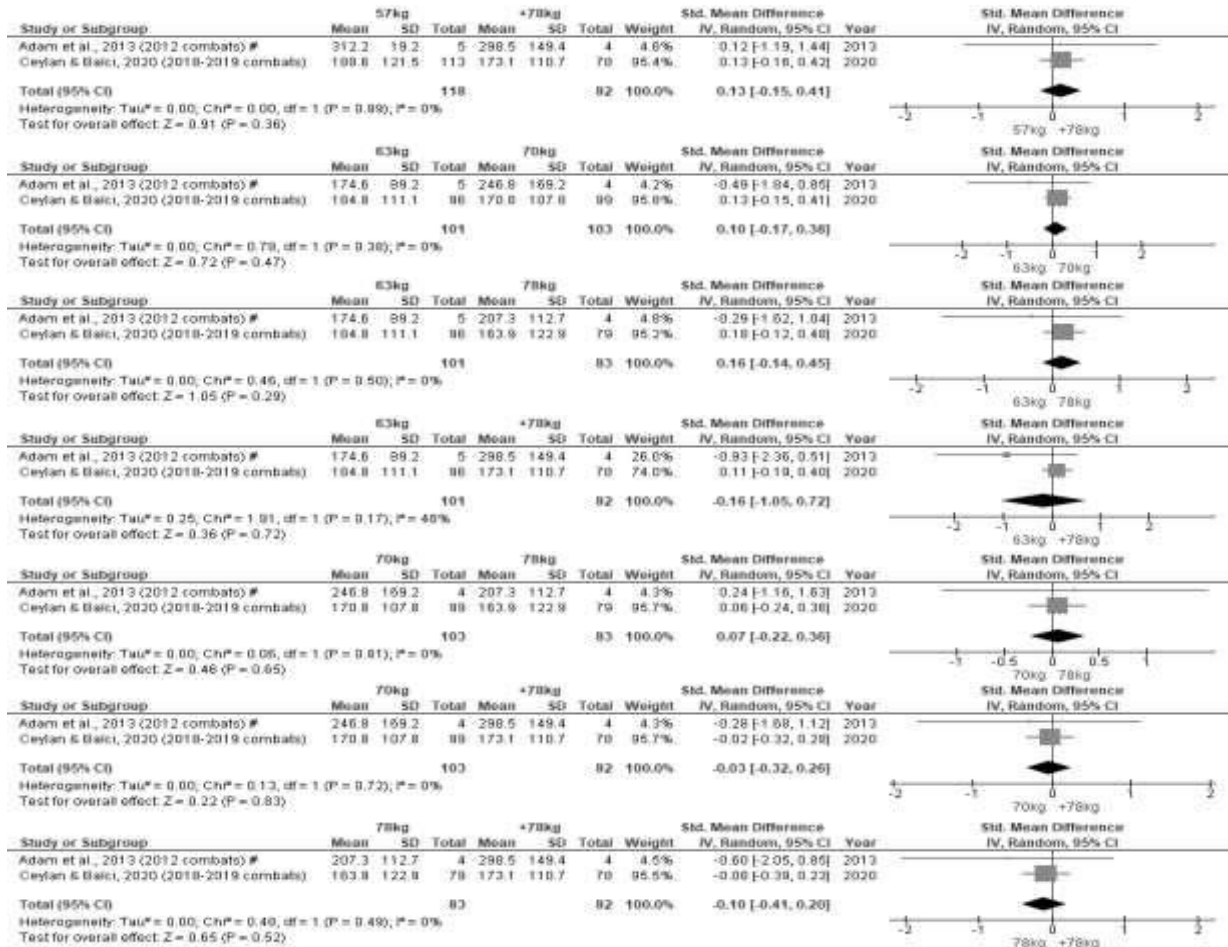


Fig. 5. Combat time of female judo by weight divisions over the years.

Average combat time by category calculated by the authors of this study

4. Discussion

This systematic review and meta-analysis aimed to synthesize literature data on female judo combat time in international competitions over the years and by weight division. Rule changes affected the total combat time over the years, and understanding how this happened could help coaches plan judo training to achieve performance. The main results showed that the average combat time changed with each rule change (2010, 2013, 2015, 2017 and 2018), and the year 2012 had a higher average combat time (Figure 3). In addition, the combat time spent between the weight divisions have become more homogeneous over the years (Figure 4).

4.1. Analysis of total female judo combat time over the years

The analysis of the average combat time from 2010 to 2019 (Figure 3) shows a curve which reached its peak in 2012 (260.9 seconds). There were rule changes in 2010 such as reducing the total time of the Golden Score from 5 to 3 minutes, prohibition of gripping techniques under the belt and elimination of the *Koka* score[3,4], and they modified the athletes' way of fighting. These changes remained in effect from January 2010 to December 2012, and they triggered several disqualification losses for performing below-the-waist gripping techniques. Over time, the athletes developed strategies to not be disqualified and at the same time induce the opponent to commit a penalty, which at the time were converted into points for the opponent. This new combat configuration encouraged adopting a defensive attitude based on combat time management (negative judo), which might have increased the average combat time in 2012.

Thus, aiming to end negative judo actions, the International Judo Federation made rule changes in 2013 in which punishments would no longer be worth points and the Golden Score time

became unlimited[3,5]. In addition, there was a new rule change in 2015 which reduced the regular female combat time from 5 to 4 minutes[3,6]. This change contributed to a reduction in combat time in 2016 (232.7 seconds) (Figure 3); however, it still consisted of 97% of the regular time[17]. These rule changes must have caused behavioral changes of athletes in combat, since winning in regular time became essential to avoid the Golden Score unlimited time. Thus, attacking effectively became more important than making the opponent suffer punishments, which would only serve to break the tie at the end of regular combat time.

The *Yuko* score was eliminated in the 2017 rules changes, the *Wazari* became a cumulative score (2 *Wazari* was no longer equivalent to an *Ippon*) and punishments would no longer decide the winner of the combat in regular time, only being useful in the Golden Score[21]. These changes were intended to encourage offensive actions, however *Wazari* accumulation was not well accepted by spectators and athletes. What happened is that the athletes with the ability and flexibility to rotate their body during the fall could be thrown six times (6 *Wazari*), and in the final minutes of the combat they would only perform one technique to obtain *Ippon* and win the combat, as their opponents would be tired from having attacked so many times. To solve this problem, a new rule change in 2018 determined that the accumulation of 2 *Wazari* would again be equivalent to *Ippon*, and the punishments stopped deciding the combat in the Golden Score[22].

The 2017 and 2018 rule changes aimed at removing the power of punishment to decide a victory, and led athletes to develop new combat strategies. Thus, the athletes developed greater technical efficiency to decide the combat before the end of regular time; however, those who had a more defensive fighting style ended up needing the Golden Score time. Table 3 and Figure 3 show this behavior change, as there was a 12.6% increase in the occurrence of combats which ended before the regular time in 2018-2019, as well as a significant increase of 13.6% ($p=0.004$) in the occurrence of the Golden Score compared to 2013 combats. These changes must have contributed to a reduction of the regular time to values below those that occurred in 2010 (2010=197.5vs. 2018-2019=180.7 seconds) (Table 2).

The analysis of the total time data in international female judo competitions over the years shows that new strategies were used by the athletes to win the combats with each rule change. Therefore, trainers need to be aware of the new combat configurations that are established after each rule change, adapting training to new combat temporal demands.

4.2. Analysis of total female combat time by weight division over the years

Analyzing the total time of female judo combats by weight division over the years is also important to identify whether there is a difference between the categories. This information can be useful in tailoring training to the specific needs of each group. As shown above (Figure 3), the regular time of women's combats from 2010 to 2019 behaved like a curve, reaching the peak time in 2012. In analyzing the behavior of time separated by weight division, Sterkovichs-Przybycien *et al.* [12], who analyzed combats from 2011-2012, and Ceylon & Balci[18], who analyzed combats from 2018-2019, did not find significant differences in combat time between the weight division. However, it is interesting to note in Figure 4 that the average combat time between categories became homogeneous after 2012, since in 2018-2019 it varied between 163.9 seconds in the 78kg category and 190.8 seconds in the 52kg category. This data indicates that the rule changes of 2013, 2015, 2017 and 2018 may have reduced the differences in behavior between female weight divisions.

The highest occurrence of the Golden Score in 2013 was in the +78kg category[19]; however, in 2018-2019, 5 out of 6 combats from the +78kg category ended with an *Ippon* before the end of regular time[18]. In addition, the 48kg category had a low occurrence of the Golden Score in both 2013 and 2018-2019[18,19]. However, no significant difference was found when we did the meta-analysis of the total combat time data between weight divisions over the years (Figure 5). This means that despite the times being more homogeneous between the categories, the change occurred in a similar way in all categories over the years. More studies are needed to identify how athletes in each weight division are behaving in each phase of combat after the 2017 and 2018 rules change.

5. Conclusions

Literature data on combat time of female judokas in international competitions over the years and by weight division were gathered in this systematic review and meta-analysis. We found that the rule changes may have caused changes in the athletes' behavior over the years, generating different combat times in each Olympic cycle. The +78kg category had the highest occurrence of the Golden Score in 2013 among all categories; however, in 2018-2019, 5 out of every 6 combats in this category ended before regular time. On the other hand, the 48kg category maintained a low occurrence of the Golden Score both in 2013 and in 2018-2019. In addition, the combat time became more homogeneous across the weight divisions in 2018-2019, although the overall occurrence of the Golden Score was higher than in previous years. Therefore, we advise that with each rule change, coaches develop new strategies to manage combat time.

With the change of rules, extreme categories, which previously had different time demands, began to spend similar times in combat. These results indicate that studies need to be constantly carried out to identify the new temporal behaviors of athletes by weight division according to new rule changes. Knowing how athletes behave in each combat phase could help coaches plan judo training, so more studies need to be conducted to understand the specific behaviors of athletes by weight division.

Authors' Contributions

Conceptualization, L.B.M.B., T.S.D., F.A., B.M. and C.J.B.; methodology, L.B.M.B., T.S.D., F.A. and B.M.; software, L.B.M.B., T.S.D., F.A., E.A.A.M., B.M.; formal analysis, investigation and resources, L.B.M.B., T.S.D., F.A., E.A.A.M., F.J.A.M., B.M. and C.J.B.; data curation, L.B.M.B., E.A.A.M., F.J.A.M. and C.J.B.; writing—original draft preparation, L.B.M.B., T.S.D., F.A. and C.J.B; writing—review and editing, E.A.A.M., F.J.A.M. and B.M.; funding acquisition, L.B.M.B. All authors have read and agreed to the published version of the manuscript."

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Conflict of interests

The authors declare no conflict of interests

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3 MÉTODO

A seguir serão apresentados os métodos que foram seguidos para realizar esse estudo.

3.1 TIPO DE PESQUISA

Este estudo é comparativo, descritivo e transversal (THOMAS; NELSON; SILVERMAN, 2012), utilizando a análise observacional do tempo-movimento (Izquierdo, 2008), que permite caracterizar as fases dos combates de judô (MIARKA, 2014) em competições de nível internacional em dois ciclos olímpicos (2016 vs. 2020). As informações coletadas possibilitaram a análise de frequência e tempo de ações em combates, sem qualquer interferência no fenômeno estudado.

3.2 DESENHO DO ESTUDO E UNIDADE DE ANÁLISE

Foram analisados 2.712 vídeos de lutas de atletas de alto nível, em competições internacionais de Judô, oriundos de dois ciclos olímpicos (2016 e 2020). Para garantir o alto nível competitivo dos atletas analisados, estes deveriam estar entre os 20 primeiros ranqueados mundialmente em cada uma das sete categorias oficiais de peso (ligeiro, meio leve, leve, meio médio, médio, meio pesado e pesado) para cada categoria de sexo, em cada ciclo. Por isso, foram solicitadas à IJF as listas do ranking mundial de atletas do sexo masculino e feminino nos dois ciclos olímpicos mencionados. A lista do ranking mundial para o ciclo 2016 foi oficialmente publicada em 30 de maio de 2016, e a do ciclo 2020 em 16 de março de 2020 (antes das competições serem interrompidas pela pandemia COVID-19).

O número de lutas analisadas por ciclo olímpico foi determinado a partir da coleta de todas as lutas encontradas do ciclo 2016, já que para este período havia menor número de vídeos disponíveis na internet em comparação ao ciclo 2020. Desse modo, as lutas foram analisadas em quantidades idênticas por ciclo olímpico, de acordo com sexo (1.332 lutas femininas: 666 por ciclo; 1.380 lutas masculinas: 690 por ciclo) e cada categoria de peso (Tabela 1).

Os vídeos foram obtidos a partir do banco de dados virtual de domínio público da IJF e do Comitê Olímpico Internacional. Desse modo, não há questões éticas já que os dados foram coletados de um acesso virtual e aberto, obtidos de forma secundária e não por

experimentação, não sendo necessário o consentimento dos atletas (AMERICAN PSYCHOLOGICAL ASSOCIATION, 2002).

Tabela 1 - Divisão por ciclo olímpico, categoria de peso e sexo das lutas de judô analisadas.

Categoria de sexo	Categoria de peso	2015-2016*	Vídeos excluídos	2019-2020*	Vídeos excluídos
Feminino	Ligeiro (48kg)	132	2	132	-
	Meio Leve (52 kg)	72	1	72	1
	Leve (57 kg)	109	1	109	-
	Meio Médio (63 kg)	96	3	96	-
	Médio (70 kg)	69	1	69	-
	Meio Pesado (78 kg)	106	3	106	2
	Pesado (+ 78 kg)	82	-	82	-
Total		666	11	666	3
Masculino	Ligeiro (60kg)	123	2	123	-
	Meio Leve (66 kg)	91	2	91	4
	Leve (73 kg)	100	2	100	-
	Meio Médio (81 kg)	102	-	102	1
	Médio – 90 kg	94	-	94	-
	Meio Pesado – 100 kg	89	1	89	-
	Pesado + 100 kg	91	-	91	1
Total		690	7	690	6

* Vídeos excluídos já retirados

Fonte: Elaborado pelo autor (2022).

Os seguintes critérios de inclusão foram utilizados para os vídeos: a) lutas realizadas com a temporalidade na íntegra, ou seja, do início ao fim do combate, inclusive com os tempos de pausa; b) filmagens feitas com visão completa da luta e do placar; c) lutas pertencentes às competições internacionais do circuito mundial de Judô (Grand Slam, Grand Prix, Campeonato Mundial e Jogos Olímpicos) realizadas nos períodos de 2015-2016 (ciclo 2016) e 2019-2020 (ciclo 2020); d) lutas de atletas que estavam entre os 20 melhores por categoria de peso e sexo na lista do ranking mundial em cada ciclo olímpico (ranking de 30/05/2016 e 16/03/2020). Foram seguidos como critérios para exclusão: a) visualização integral da luta impedida por situações como: posição do árbitro impossibilitando a

observação das ações dos lutadores; imagens desfocadas ou de baixa qualidade (definição padrão 480p); b) situações em geral que prejudicaram a análise do combate (vídeo replay dos árbitros, impedindo a visualização de parte da luta, vídeo travando, etc.). Os vídeos das lutas analisadas pertenciam às seguintes competições internacionais de judô:

- a) Ciclo 2016 – 19 Grand Prix (Almaty 2016, Budapeste 2015 e 2016, Dusseldorf 2015 e 2016, Havana 2016, Jeju 2015, Qingdao 2015 e 2016, Samsun 2015 e 2016, Tashkent 2015 e 2016, Tbilisi 2015 e 2016, Ulaanbaatar 2015 e 2016, Zagrebe 2015 e 2016); 10 Grand Slam (Abu Dhabi 2015 e 2016, Baku 2015 e 2016, Paris 2015 e 2016, Tóquio 2015 e 2016, Tyumen 2015 e 2016); o Campeonato Mundial Astana 2015 e os Jogos Olímpicos Rio 2016.
- b) Ciclo 2020 – 10 Grande Prix (Antalaya 2019, Budapeste 2019, Hohhot 2019, Marrakech 2019, Montreal 2019, Tashkent 2019, Tbilisi 2019, Tel Aviv 2019 e 2020, Zagrebe 2019); 5 Grand Slam (Abu Dhabi 2019, Baku 2019, Brasília 2019, Dusseldorf 2019 e 2020); e o Campeonato Mundial Tóquio 2019.

3.3 INSTRUMENTOS E PROTOCOLO DE COLETA DE DADOS

Para realização desta pesquisa foi utilizado: a) um computador portátil (Samsung, Brasil) com acesso à internet para captação dos vídeos; b) o programa computacional validado e gratuito Frami[®] (MIARKA *et al.*, 2011), para análise das filmagens; c) o programa gratuito VLC media player 3.0.4 para compatibilizar as filmagens no Frami[®]. Na análise dos vídeos foram quantificados os tempos gastos nas fases do combate de judô propostas por protocolo validado (MIARKA, 2014), descritos a seguir:

- a) Aproximação – tempo entre o sinal do árbitro de início de combate e a realização do primeiro contato entre os atletas com tentativa de pegada.
- b) Pegada – tempo entre a realização da pegada (permanência mínima de 1 segundo) e o ataque, tem como referência o *judogui* do oponente.
- c) Ataque – tempo entre a preparação (*tsukuri*) e a projeção (*kake*) de uma técnica de ataque, conforme a regra vigente no ciclo olímpico do combate (INTERNATIONAL JUDO FEDERATION 2013, 2015, 2017a, 2017b). Para ser considerado ataque, era necessário que a técnica chegasse na fase do *kake*, ou seja, o oponente deveria perder o contato com o solo de pelo menos um pé.

- d) Defesa – tempo de movimentação do atleta para proteger-se do ataque adversário evitando a queda (esquiva ou bloqueio corporal) ou realização de um contra-ataque (execução de técnicas de ataque resultantes de antecipação das ações do adversário no momento em que este realizava um ataque).
- e) Solo – tempo em que os dois lutadores realizam movimentos com o objetivo de executar técnicas no solo, conforme a regra vigente no ciclo olímpico do combate (INTERNATIONAL JUDO FEDERATION 2013, 2015, 2017a, 2017b).
- f) Pausa – tempo entre a interrupção e o reinício do combate pelo árbitro.

3.4 PROCEDIMENTOS PARA COLETA DE DADOS

Uma das maiores limitações do uso da metodologia observacional é o próprio observador, por isso, é necessário que haja critérios que garantam que o avaliador consegue traduzir as condutas observadas para os dados, além de ser necessária a mensuração da fiabilidade do seu registro observacional (IZQUIERDO, 2008). A avaliadora expert que fez as análises desse estudo era faixa preta 2º Dan em judô (grau atribuído e reconhecido pela confederação nacional do esporte), possuía vivência superior a 25 anos no esporte e tem experiência competitiva à nível nacional.

Além disso, para desenvolver e aprimorar a habilidade de análise observacional do tempo-movimento das lutas, a avaliadora realizou um treinamento com duração de 12 horas para familiarização com os botões e comandos do programa computacional Frami®, bem como, para padronização da técnica de análise do protocolo validado (MIARKA, 2014). Com base nas dificuldades encontradas durante o treinamento, foram feitos alguns ajustes aos botões de comando do Frami® de modo a reduzir o tempo gasto na análise de cada vídeo, diminuindo o número de “cliques” para facilitar a coleta de dados e sua posterior análise.

Para verificar a fiabilidade da análise da expert e garantir a confiabilidade da análise dos dados, foram analisados 20 vídeos de lutas internacionais de judô, sendo 10 de cada ciclo olímpico para garantir a análise das lutas em diferentes aplicações da regra. Estas lutas foram sorteadas por outra pessoa a partir do banco de vídeos disponível no canal virtual da IJF (coletados nos anos de 2018, 2019 e 2020), e então, cada vídeo recebeu um código. A análise das lutas foi realizada pela avaliadora e após 1 semana reanalisadas randomicamente. Os dados da fiabilidade poderão ser vistos no capítulo 4.

Em seguida, foi realizado um estudo piloto com a análise de 680 combates de judô masculino, para consolidação da escolha dos procedimentos, materiais e métodos estatísticos

propostos nessa pesquisa. A realização do estudo piloto foi relevante para direcionar a análise dos dados desta pesquisa, pois foi detectado que apesar dos atletas masculinos do ciclo 2020 apresentarem tempo total de combate menor do que os atletas do ciclo 2016, no ciclo 2020 a ocorrência e o tempo gasto no *Golden Score* aumentaram. Esse resultado despertou para o fato de que seria necessário realizar uma análise separando os combates por momento de término (Tempo regular versus *Golden Score*) para compreender melhor o comportamento temporal dos combates de judô entre os ciclos Olímpicos.

O estudo piloto foi publicado em revista internacional como artigo original (BARRETO *et al.* 2021). O resumo do artigo está no capítulo 5 e pode ser encontrado na íntegra no seguinte link:

<https://www.tandfonline.com/doi/abs/10.1080/24748668.2021.1979839?journalCode=rpan20>

3.5 TRATAMENTO ESTATÍSTICO DOS DADOS

Para análise dos dados foi utilizado o programa *Statistical Package for Social Science* 22.0 (SPSS) considerando nível de significância de $p < 0,05$. Para caracterizar os grupos de análise (categorias de peso, ciclo olímpico, combates terminados até o Tempo Regular ou no *Golden Score*) foi utilizada estatística descritiva com cálculos das médias, desvios-padrão (DP), intervalo das variáveis paramétricas, ou medianas, primeiro e terceiro quartis, percentual de ocorrência para variáveis não paramétricas (BARROS; REIS, 2003).

Para verificar a fiabilidade da análise da expert foi aplicado o Coeficiente de Correlação Intraclasse (ICC), pois as medidas de tempo em segundos são quantitativas (MORROW JR *et al.*, 2014). Para classificar os níveis de concordância entre as análises intra-avaliadora, foi utilizada a distribuição proposta por Koo, Li (2016) para ICC ($< 0,5$ fraca; $0,5 - 0,75$ moderada; $0,76 - 0,9$ bom; $> 0,91$ excelente).

Na análise do estudo piloto (BARRETO *et al.* 2021) foi utilizado o teste t de Student para amostras independentes para verificar as diferenças entre as variáveis por ciclo olímpico, e o Qui-quadrado para comparar a ocorrência do *Golden Score* nos combates por ciclo olímpico.

Na análise dos dados desse estudo, para verificar as diferenças entre os dois períodos olímpicos e entre grupos), foram realizadas comparações por meio de uma ANOVA (análise de variância com medidas repetidas) com fatores independentes (categoria de peso e ciclo ou momento de fim do combate) e *post hoc* de Bonferroni (BARROS; REIS, 2003; MORROW JR *et al.*, 2014).

4 FIABILIDADE DA ANÁLISE DAS LUTAS DE JUDÔ

Neste capítulo está a análise da fiabilidade dos dados coletados. Foram analisados 20 vídeos de lutas de judô, e reanalisados 1 semana depois, seguindo o protocolo validado por Miarka (2014). Na Tabela 2 podem ser encontradas as médias e desvio padrão do tempo (em segundos) gasto em cada fase da luta de judô.

Tabela 2 - Fiabilidade da análise das fases de lutas de judô.

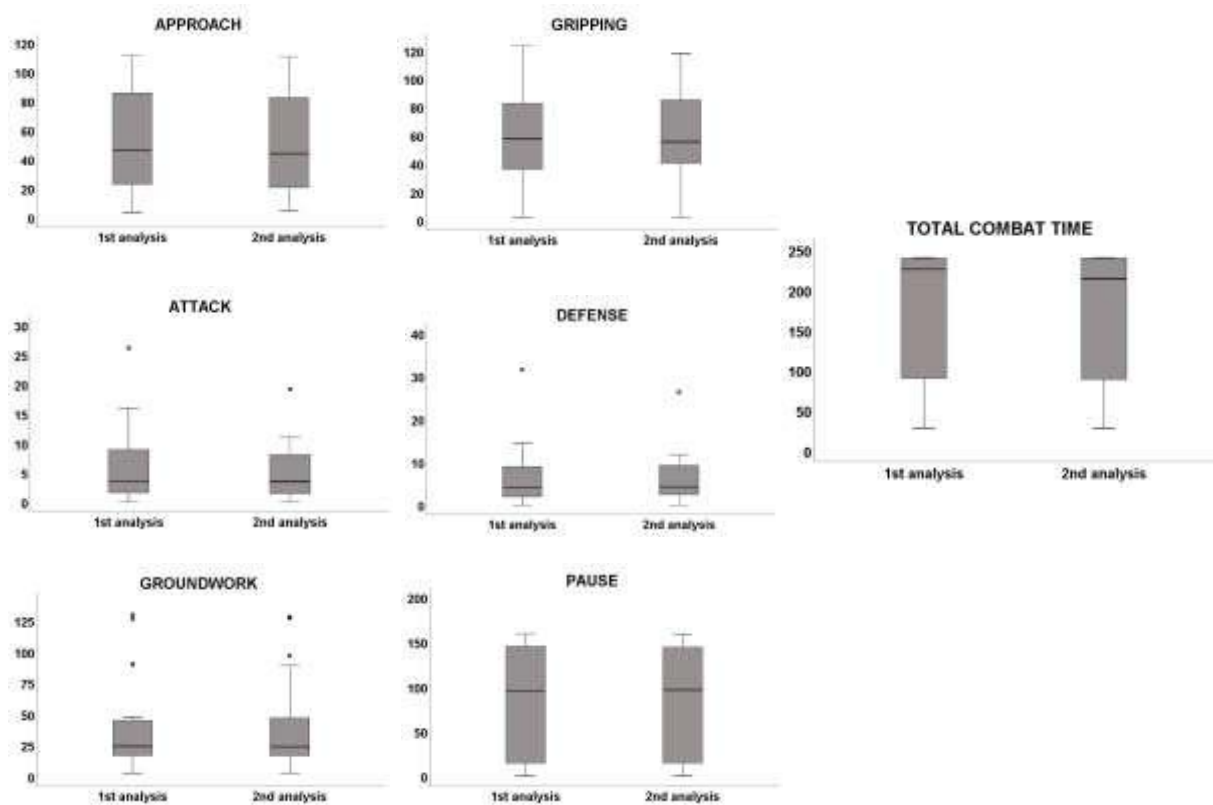
Fase da luta	M±SD (s) teste / reteste	Fiabilidade (ICC)	Intervalo de Confiança (95%)	Classificação
Aproximação	52,1±36,6 / 50,3±35,4	0,99	0,99; 0,99	Excelente
Pegada	59,3±34,2 / 60,7±34,1	0,99	0,99; 0,99	Excelente
Ataque	5,9±6,8 / 5,1±4,9	0,95	0,88; 0,98	Excelente
Defesa	6,4±7,3 / 6,3±5,8	0,97	0,92; 0,99	Excelente
Solo	39,7±38,02 / 39,5±38,7	0,99	0,99; 1	Excelente
Pausa	80,1±64,6 / 79,8±64,1	0,99	0,99; 1	Excelente
Tempo total	163,5±83,9 / 161,9±82,7	0,99	0,99; 1	Excelente

M – média; SD – desvio padrão; s – segundos; ICC – Coeficiente de Correlação Intraclasse.

Fonte: Elaborado pelo autor (2022).

Na Figura 3 podem ser visualizadas as comparações do teste e reteste de cada fase. Houve concordância “excelente” para a análise de todas as fases da luta de judô. De modo similar, Miarka (2015) verificou a confiabilidade nas análises de 20 vídeos de lutas de judô feitas por um expert com experiência superior a 10 anos em judô, e encontrou classificação “quase perfeita” para 87% das variáveis analisadas referentes às ações em cada fase de combate. Ando et. al. (2016) além de analisarem a confiabilidade, verificaram a objetividade entre análises de vídeos por experts em judô. No estudo 6 avaliadores, professores de judô com mais de 10 anos de prática na modalidade e experiência competitiva nacional ou internacional, fizeram análise e reanálise de 10 vídeos de luta. Todos passaram por treinamento com duração entre 7 a 12 horas para familiarização com os comandos e botões do programa Frami[®]. Ando et. al. (2016) encontraram objetividade e confiabilidade “quase perfeita” para as análises da estrutura temporal, ações técnico-táticas e pontuações dos combates.

Figura 3 - Análise e reanálise das fases de combates de judô pela mesma expert.



* $p < 0,05$

Fonte: Elaborado pelo autor (2022)

Diante dos resultados da análise de fiabilidade deste estudo e dos dados encontrados na literatura, consolida-se a ideia de que existe confiabilidade na análise das fases da luta de judô por experts, desde que os mesmos tenham experiência superior a 10 anos no esporte, e que sejam submetidos a um pré-treinamento com duração mínima de 7 horas para familiarização com o programa Frami[®] e o protocolo de análise (ANDO *et al.*, 2016; MIARKA *et al.*, 2015). Portanto, a avaliadora que fez a análise dos vídeos de combates de judô nesta pesquisa estava capacitada para realizar a coleta de dados, haja vista que além de atender os pré-requisitos de expertise no esporte (faixa preta 2º Dan; vivência >25 anos no esporte; experiência competitiva à nível nacional), participou de um treinamento de 12 horas para aprender a utilizar o software Frami[®] e o protocolo tempo-movimento de análise dos combates. Ademais, a confiabilidade na análise dos dados foi “excelente” (Tabela 2 e Figura 3).

5 ESTUDO PILOTO

Por respeito ao direito de uso e reprodução do periódico científico em que o artigo foi publicado, disponibilizou-se apenas o resumo do estudo (Figura 4), que está em inglês por se tratar de revista internacional e segue a formatação da revista.

Figura 4 - Estudo piloto para consolidação da escolha dos procedimentos, materiais e métodos estatísticos desta pesquisa.



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Research Article

Road to Tokyo Olympic Games: do new judo rules change the technical-tactical behaviour of elite male athletes?

Lindsei Brabec Mota Barreto , Esteban Ariel Aedo-Muñoz , Dany Alexis Sorbazo Soto , Bianca Miarka  & Ciro Jose Brito 

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ABSTRACT

This study compared the time-motion of the combat phases in male judo within two Olympic cycles (2016 vs. 2020). We analysed of 680 combats from belonging to two Olympic cycles (340 combats 2015–2016 and 340 combats 2019–2020). The combat phase was quantified according to a validated protocol (approach, gripping, attack/defence, groundwork, and pause). The 2020 cycle athletes spent less time in the gripping (79.7 ± 50.1 vs. 104.3 ± 54.1 seconds; $p < 0.001$), attack/defence (7.6 ± 5.2 vs. 9.5 ± 7.2 seconds; $p < 0.001$), and groundwork phases (33.9 ± 29.0 vs. 42.2 ± 32.0 seconds; $p < 0.001$), and ashorter total combat time (200.0 ± 104.6 vs. 238.0 ± 94.8 seconds; $p < 0.001$) than the 2016 athletes. Additionally, the 2020 athletes had ahiger occurrence of Golden Score (0.3 ± 0.4 vs. 0.1 ± 0.2 of total combats; $p < 0.001$), and ahiger time spent in the Golden Score (23.9 ± 53.5 vs. 4.1 ± 21.4 seconds; $p < 0.001$). The 2016 athletes had alonger total combat time; however, the time spent on the Golden Score increased in the 2020. These results should be helpful in preparing technical-tactical training aimed at performance.

KEYWORDS: Martial arts time and motion analysis rules judo

Fonte: BARRETO *et al.*, 2021.

6 RESULTADOS E DISCUSSÃO

Esse estudo teve por objetivo verificar o impacto das modificações das regras do judô dos ciclos Olímpicos 2016 e 2020 sobre o tempo total, fases temporais e relação esforço-pausa de combates internacionais entre divisões de peso nas categorias masculina e feminina, comparando inclusive os combates por momento de término (Tempo regular versus *Golden Score*).

As análises dos dados resultaram em 4 artigos que estão sendo encaminhados para publicação em revistas científicas internacionais. Desse modo, para uma organização didática dos resultados e discussão, os artigos foram distribuídos em subcapítulos nos quais se encontram as seguintes análises:

- a) Análise do tempo total do combate masculino por divisão de peso e momento de término entre ciclos olímpicos 2016 versus 2020: artigo original aprovado e em processo de publicação na revista *International Journal of Performance Analysis in Sport* sob o título *Has there been a change between combat time in male judo? Analysis of the top 20 athletes by weight division between the 2016-20 Olympic cycles* (Barreto *et al.*, 2022c). O resumo do artigo está no subcapítulo 6.1 e pode ser encontrado na íntegra no seguinte link:
<https://www.tandfonline.com/doi/abs/10.1080/24748668.2022.2086516?src=&journalCode=rpan20>
- b) Análise do tempo total do combate feminino por divisão de peso e momento de término entre ciclos olímpicos 2016 versus 2020: artigo original em processo de submissão em revista científica.
- c) Análise do tempo das fases do combate masculino e da relação esforço-pausa por divisão de peso e momento de término entre ciclos olímpicos 2016 versus 2020: artigo original em processo de submissão em revista científica.
- d) Análise do tempo das fases do combate feminino e da relação esforço-pausa por divisão de peso e momento de término entre ciclos olímpicos 2016 versus 2020: artigo original em processo de submissão em revista científica.

Os textos dos artigos estão em inglês e a formatação está seguindo as normas das respectivas revistas às quais estão sendo submetidas.

6.1 ANÁLISE DO TEMPO TOTAL DO COMBATE MASCULINO POR DIVISÃO DE PESO E MOMENTO DE TÉRMINO ENTRE CICLOS OLÍMPICOS 2016 VERSUS 2020

Por respeito ao direito de uso e reprodução do periódico científico em que o artigo foi publicado, disponibilizou-se apenas o resumo do estudo (Figura 5), que está em inglês por se tratar de revista internacional e segue a formatação da revista.

Figura 5 - Análise do tempo total do combate masculino por divisão de peso e momento de término entre ciclos olímpicos 2016 versus 2020.

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Has there been a change between combat time in male judo? Analysis of the top 20 athletes by weight division between the 2016-20 Olympic cycles

Lindsey Brabec Mota Barreto, Esteban Ariel Aedo-Muñoz, Dany Alexis Sorbazo Soto, Bianca Mlarka & Ciro José Brito

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ABSTRACT

This study compared male judo combat time in international competitions between the 2016 and 2020 Olympic cycles, by weight divisions. We analysed 1380 videos of male judo combat from top 20 in the World ranking by weight division. The 2020 cycle had a lower combat time and a higher occurrence of Golden Score (GS) compared to the 2016 cycle (combat time: 2020= 206.9, 2016= 240.3 seconds; GS time: 2020= 95.1, 2016= 77.6 seconds; $p < 0.001$; GS occurrence: 2020= 27%, 2016= 6%; $p < 0.05$). The 66kg and 73kg spent the most time and the +100kg category spent the least time in the GS than the other divisions, in both Olympic cycles. However, in the 2020 cycle compared to 2016, the 66kg was the only that reduced the combat time on the GS ($p = 0.002$), the 81kg and +100kg had a change in the distribution of combat closure minute-by-minute [81kg(2016)= 28%, 81kg(2020)= 68% finished until the 4th minute of Regular Time; +100kg(2016)= 25%, +100kg(2020)= 50% finished until the 3rd minute of Regular Time; $p = 0.003$ for both]. These data must be considered when prescribing male judo training for specific performance.

KEYWORDS: Martial arts, combat sports, time and motion studies, performance, task performance and analysis

Fonte: BARRETO *et al.*, 2022c.

6.2 ANÁLISE DO TEMPO TOTAL DO COMBATE FEMININO POR DIVISÃO DE PESO E MOMENTO DE TÉRMINO ENTRE CICLOS OLÍMPICOS 2016 VERSUS 2020

Combat Time of Female Judo competition between 2016 and 2020 Olympic Cycles: an analyze of top-20 athletes by weight division

Female Judo Combat Time in 2016/2020 Olympic Cycles

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Abstract

This study compared the female judo combat time in international competitions between two Olympic cycles (2016 vs. 2020), verifying differences between weight divisions. We analyzed 1,332 judo combat videos (2016=666; 2020=666) of the top 20 athletes in the World rankings in each division. There was no significant difference ($p \leq 0.05$) in the combat time between cycles; however, there was a significant difference in the analysis of when the combat ended. The 2020 cycle had a higher occurrence of Golden Score (2020=20%; 2016=9%; $p < 0.001$), a lower time of combats that ended until regular time (2020=155.3; 2016=191.9 seconds; $p < 0.001$); and longer time of combats that ended in the Golden Score (2020=122.1; 2016=89.8 seconds; $p < 0.001$). Regarding the analysis by weight divisions, the 70kg (2020) and +78kg (2020) categories had a significantly lower combat time than the others [70kg (2020); +78kg (2020) vs. 48kg (2016; 2020), 57kg (2020); +78kg (2020) vs. 52kg (2016, 2020), 57kg (2016), 78kg (2016)]. There was an increase in the occurrence of Golden Score in the 48kg (2020) (+18%, $p < 0.001$), 63kg (2020) (+17%, $p = 0.001$) and 78kg (2020) (+21%, $p < 0.001$) compared to 2016 cycle. The 78kg category had a higher Golden Score occurrence than the +78kg. These data must be taken into account in the training prescription, since the rule changes had different effects in each division.

Keywords: martial arts; combat sports; time and motion studies; performance; task performance and analysis.

1. INTRODUCTION

Important changes in female judo rules occurred in the 2016 and 2020 Olympic cycles (3,28,41). In the 2016 cycle, the International Judo Federation decided in the 2013 rules that punishments were no longer worth points and the time of the Golden Score became unlimited (21); and in the 2015 rules there was a reduction in the normal combat time of 5 to 4 minutes (22). In the 2020 cycle, the 2017 rule changes extinguished the *Yuko* score and removed the winner's decision for penalty in the regular time (23); in 2018, punishments also stopped deciding the combat in the Golden Score (24). The scientific paradigm for these modifications has been partially verified, and evidence-based investigations could demonstrate a reverse tendency of the rule changes, i.e., increasing the Golden scores in male combats (4,8,18). The combat time analysis is frequently used within research and applied settings to investigate combat demands of female judo combats (19,33,39); however, practical evaluation of rules changes and combat effort mechanisms requires knowledge of the weight categories differences that can potentially affect the physiological (2,36,44), technical (40) psychological (7,16), and tactical performance in high-level female judo athletes (34,26).

The requirement to produce an accurate recording of an event and then analyze and diagnose it and afford feedback to athletes and coaches to increase performance is not new in judo (9). Initial investigations described information about effort and recovery required in male combats. For instance, Castarlenas and Planas (9) observed that usually, judo combats present eleven work sequences per seven pause sequences. These authors demonstrated that effort sequences last for about 15s to 30s, with pause breaks of about 10s. Admirable accounts that outline the historical improvement of this field in a wide range of female judo studies are available (11,19,32,43). However, there is limited information on rules changes and combat demands of female judo athletes, considering weight divisions.

The Olympic Games provide the chance for women to acquire up to seven medals, one for each competitive weight category, for their representative country; however, applied combat time information knowledge Olympic female judo competitions is occasional. A primary combat analysis research indicated a median of 7 sequences of combat: pause cycles during women combats of 2008 (30). Up until the 2012 Olympic Games, competitive female judo combats were five minutes with a three-minute Golden Score potential (20). Findings with women have displayed specific conditional observations, which could affect combat time and determine competitive success, such as the correlation between the approach phase of combat and gripping (5), effective attacks and their orientations (42,29), gripping patterns and

throwing side analysis (12,27), and penalties on subsequent attack effectiveness (15,14); while the relationship amongst these skills represents the primary aspects of female attacking systems (13,35). These data could improve physiological, psychological and tactical performance, as in intermittent practices for physical training sections; however, the large number of rules changes between 2016 and 2020 Olympic Cycles could impact specific physical demands in judo (17).

Rules changes were intended to discourage extremely defensive actions (negative judo) that valued punishments rather than attacks (21,23,24), besides making judo more dynamic and attractive (22,37). These changes likely affected the way athletes fight and the time spent in combat, as some studies that analyzed female combats showed different combat time averages for 2016 competitions (6) and 2018 and 2019 competitions (10). However, no rules change studies were found with detailed information comparing the total combat time between different Olympic cycles and by women weight division. Thus, the objective of this study was to compare the female judo combat time in international competitions between the 2016 and 2020 Olympic cycles, verifying differences between the weight divisions. Identifying how changes in rules may have influenced the combat time spent in each Olympic cycle can help predict temporal combat actions, aiding in the physical and technical-tactical preparation of the judokas. Thus, judo coaches will provide information that would help them to make decisions about which strategies to use in the face of a new rule change. We hypothesized that there will be a difference in the combat time between these two Olympic cycles.

2. METHODS

2.1. Experimental Approach to the Problem

The present documental and descriptive study analyzed 1,332 female judo combat videos from two Olympic cycles (2016 and 2020). The distribution of combats by weight division was identical (48kg=132; 52kg=72; 57kg=109; 63kg=96; 70kg=69; 78kg=106; +78kg=82; total=666 combats/cycle). All combats from the 2016 cycle were collected after the 2015 rule change that reduced the regular female combat time from 5 to 4 minutes (22), so, the combats were from 2015 and 2016 competitions. All combats of the 2020 cycle took place before the competitions were interrupted by the COVID-19 pandemic, so they were competitions from 2019 to March 2020.

2.2. Participants

The athletes, who participated in the analyzed combats, were among the top 20 in each weight division on the World Ranking released by the International Judo Federation (ranking of May 30, 2016; ranking of March 16, 2020). The sample calculation representing female international combats obtained a 99% confidence level and 1% margin of error, using the equation below (25):

$$n = N Z^2 p (1-p) / e^2 + Z^2 p (1-p)$$

The interpretation of each of these elements is made as follows:

n = is the sample size obtained through the calculation;

N = total combats belonging to the years (2015-2016/ 2019-2020);

Z = indicated deviation from the acceptable mean value for the confidence level to be reached;

e = is the maximum margin of error that the search allows;

p = is the proportion we want to find in the calculation.

The analyzed combats videos belonged to the following international judo competitions: 26 Grand Prix (Almaty 2016; Antalya 2019; Budapest 2015, 2016, 2019; Dusseldorf 2015, 2016; Havana 2016; Hohhot 2019; Jeju 2015; Marrakech 2019; Montreal 2019; Qingdao 2015, 2016; Samsun 2015, 2016; Tashkent 2016, 2019; Tbilisi 2015, 2016, 2019; Tel Aviv 2019, 2020; Ulaanbaatar 2016; Zagreb 2016, 2019); 11 Grand Slam (Abu Dhabi 2015, 2016, 2019; Baku 2015, 2016, 2019; Paris 2016; Tokyo 2015, 2016; Tyumen 2015, 2016); 2 World Championship (Astana 2015; Tokyo 2019); and the Rio 2016 Olympic Games. The combat videos were collected on the International Judo Federation's virtual channel, and were of sufficient quality (standard 480/60i) for analysis, as well as they had a panoramic view of the entire competition area. Since the analyzed videotapes are in the public domain, it was not necessary to acquire informed consent from the athletes concerned (1).

2.3. Procedures

For the analysis, present research applied a validated protocol using the free computer programs Frami[®] (31) and VLC media player 3.0.4. The expert who analyzed the videos had more than 25 years of judo practice and underwent 12-hour training to become familiar with the buttons and commands of the Frami[®], as well as the combat analysis protocol. The expert's reliability was verified through 20 videos of judo combats that were analyzed and reanalyzed, with an interval of 1 week. There was "excellent" agreement for the analysis of combat time (Intraclass Correlation Coefficient =0.99; confidence interval =0.99;1).

For data analysis, we made comparisons between the Olympic cycles and between the weight divisions of the following variables: a) average combat time in seconds; b) moment when the combats ended (Regular Time or Golden Score); c) end-of-combats period from minute to minute [Within regular time: ≤ 1 min (1-60 seconds), ≤ 2 min (61-120 seconds), ≤ 3 min (121-180 seconds), < 4 min (181-239 seconds), Regular time (240 seconds); in the Golden Score after the end of the regular time: $GS \leq 1$ min (1-60 seconds), $GS \leq 2$ min (61-120 seconds), $GS \leq 3$ min (121-180 seconds), $GS \leq 4$ min (181-240 seconds), $GS + 4$ min (more than 240 seconds)].

2.4. Statistical Analysis

Statistical analysis was processed in the SPSS software (version 20.0; SPSS, Inc., Chicago, IL, USA), with a significance level of $p < 0.05$. To check the reliability between the videos analyzed by the expert, we used the Intraclass Correlation Coefficient test and this confidence interval. Descriptive data were presented as mean, standard deviation, minimum, maximum and percentage. Student's T test for independent samples and ANOVA for independent factors were used to verify the differences between combat time per Olympic cycle and per weight division. To compare the proportions of combats by finishing period, we used the Man-Whitney U Test and Z Test.

3. RESULTS

Table 1 shows female judo combat time by Olympic cycle (2016 vs. 2020) and by weight divisions. There was no significant difference in total combat time between the 2016 and 2020 ($p = 0.183$). There were significant differences in total combat time between the following weight divisions: a) The 70kg (2020) vs. 48kg (2016;2020) ($p = 0.001$ for both), vs. 57kg (2020) ($p = 0.002$). The 70kg (2020) had a lower combat time (162.7 seconds) than 48kg (2016) = 226.1 seconds; 48kg (2020) = 225.5 seconds and; 57kg (2020) = 225 seconds; The +78kg (2020) vs. 48kg (2016; 2020) ($p < 0.001$ for both), 52kg (2016) ($p = 0.008$), 52kg (2020) ($p = 0.016$), 57kg (2016) ($p = 0.006$), 57kg (2020) ($p < 0.001$) and; 78kg (2016) ($p = 0.009$). The +78kg (2020) showed a lower combat time (147.3 seconds) than 48kg (2016) = 226.1 seconds; 48kg (2020) = 225.5 seconds; 52kg (2016) = 207.7 seconds; 52kg (2020) = 205.2 seconds; 57kg (2016) = 203.3 seconds; 57kg (2020) = 225 seconds; 78kg (2016) = 202 seconds.

Table 1. Female judo combat time in the 2016 and 2020 Olympic cycles (n=1332), according weight divisions.

Weight divisions (combats per cycle)	Combat time (seconds) (mean ± standard deviation/ minimum; maximum)		p
	2016	2020	
All categories (n=666)	204.3±79.5/ 6.3; 594.9	197.2±111.9/ 10.8; 623.4	0.183
48 kg (n=132)	226.1±59/ 24.6; 378.3 ^{###}	225.5±119.9/ 36.5; 524.5 ^{###}	1.000
52 kg (n=72)	207.7±86/ 10; 443.1 ^{##}	205.2±123.8/ 27.7; 623.4 ^{##}	1.000
57kg (n=109)	203.3±93.6/ 6.3; 594.9 ^{##}	225±128.1/ 29.7; 614.3 ^{###}	1.000
63 kg (n=96)	195.8±77.9/ 16.6; 361.8	195.5±103.1/ 10.8; 548.9	1.000
70 kg (n=69)	196.3±87.9/ 34.6; 468.1	162.7±101.6/ 36.3; 517.2 [#]	1.000
78 kg (n=106)	202±69.7/ 11.2; 354.5 ^{##}	190.5±100.5/ 13.1; 456.9	1.000
+78kg (n=82)	187.1±83.6/ 7.8; 479.6	147.3±64/ 18; 279.2 ^{##}	0.686

Significant difference: [#]70kg (2020) vs: 48kg (2016, 2020), p=0.001; 57kg (2020), p=0.002; ^{##}+78kg (2020) vs: 48kg (2016, 2020), p<0.001 for both; 52kg (2016), p=0.008; 52kg (2020), p=0.016; 57kg (2016), p=0.006; 57kg (2020), p<0.001; 78kg (2016), p=0.009.

Tables 2 and Fig. 1 show the average combat time and the significant difference in the comparison by weight divisions. There was a significant difference between groups: in the 2020 cycle the time spent in combats that ended up to Regular time was lower (2020=155.3 vs. 2016=191.9 seconds; p<0.001) and the time spent in combats that required a Golden Score was higher (2020=122.1 vs. 2016=89.8 seconds; p<0.001) than in 2016 cycle.

There was significantly lower time spent in combats that ended in Regular Time in the 2020 than in the 2016 cycle for almost weight divisions (except 57kg). In addition, within the 2016 cycle there was a significant difference between the 48kg vs. 52kg (p=0.015), 57kg and 70kg (p=0.001 for both), 63kg (p=0.011), +78kg (p<0.001), and the +78kg vs. 78kg (p=0.039). The 48kg spent more regular combat time than others (48kg = 214.9 seconds vs. 52kg = 188 seconds; 57kg = 181.6 seconds; 63kg = 189.8 seconds; 70kg = 179.2 seconds; +78kg=176.4 seconds) and the +78kg spent lower regular combat time than the 78kg (+78kg = 176.4 seconds vs. 78kg = 198.4 seconds). Within the 2020 cycle there was significant difference between the 57kg vs. 78kg (p=0.014) and +78kg (p=0.006), and the 70kg vs. 48kg (p=0.002), 52kg (p=0.005), 57kg (p<0.001) and; 63kg (p=0.023). The 57kg spent more regular combat time than others (57kg = 175.8 seconds vs. 78kg = 149 seconds; +78kg = 145.7 seconds). The 70kg spent a lower regular combat time than others (70kg = 128 seconds

vs. 48kg = 165.3 seconds; 52kg = 156.1 seconds; 57kg = 175.8 seconds; 63kg = 156.3 seconds).

Table 2. Female combat time separated by combat ending time (2016 vs. 2020 Olympic cycle), according weight divisions.

Group	End of combat (u)	Combat time (s)		P
		2016	2020	
Total (n=666 per cycle)	Regular time (2016=606; 2020=530)	191.9±69.1	155.3±70.1	<0.001*
	Golden Score ¹ (2016=60; 2020=136)	89.8±68.8	122.1±91.6	<0.001*
48 kg (n=132 per cycle)	Regular time (2016=117; 2020=94)	214.9±51.6	165.3±69	<0.001*
	Golden Score ¹ (2016=15; 2020=38)	73.3±36.1	134.4±83.3	<0.001*
52 kg (n=72 per cycle)	Regular time (2016=63; 2020=56)	188±9.6	156.1±10.2	0.014*
	Golden Score ¹ (2016=9; 2020=16)	105.6±67.7	137.1±113.1	0.014*
57 kg (n=109 per cycle)	Regular time (2016=94; 2020=86)	181.6±73.3	175.8±74.2	0.584
	Golden Score ¹ (2016=15; 2020=23)	99.9±93.3	179.8±109.9	<0.001*
63 kg (n=96 per cycle)	Regular time (2016=91; 2020=75)	189.8±75	156.3±71.2	0.002*
	Golden Score ¹ (2016=5; 2020=21)	64.8±44.6	95.4±73.7	0.046*
70 kg (n=69 per cycle)	Regular time (2016=61; 2020=57)	179.2±73.9	128±67.1	<0.001*
	Golden Score ¹ (2016=8; 2020=12)	87±78.6	87.6±70.6	0.965
78 kg (n=106 per cycle)	Regular time (2016=103; 2020=81)	198.4±67.3	149±67.1	<0.001*
	Golden Score ¹ (2016=3; 2020=25)	85.6±25.1	85.4±66.2	0.991
+78 kg (n=82 per cycle)	Regular time (2016=77; 2020=81)	176.4±71.1	145.7±62.6	0.006*
	Golden Score ¹ (2016=5; 2020=1)	112.5±95.4	39±0	0.03*

¹ Golden Score= total combat time - regular time in each Olympic cycle (240 seconds); u - unit; s – seconds; * Significant difference.

Regarding the combats that ended in the Golden Score, the light and medium divisions spent more time in the 2020 cycle Golden Score than in the 2016 cycle: 48kg: (2020 = 134.4 seconds, 2016 = 73.3 seconds); 52kg (2020 = 137.1 seconds, 2016 = 105.6 seconds); 57kg (2020 = 179.8 seconds, 2016 = 99.9 seconds); 63kg (2020 = 95.4 seconds, 2016 = 64.8 seconds). The +78kg showed a lower Golden Score time in the 2020 cycle (2020=39 seconds, 2016=112.5 seconds). In addition, within the 2016 cycle there was a significant difference between the 48kg vs. 52kg (p=0.013), 57kg (p=0.018) and +78kg (p=0.014), and the 63kg vs. 52kg (p=0.018), 57kg (p=0.028) and +78kg (p=0.014). The 48kg and 63kg spent a lower Golden Score time than others (48kg = 73.3 seconds and 63kg = 64.8 seconds vs. 52kg =

105.6 seconds; 57kg = 99.9 seconds; +78kg = 112.5 seconds). Within the 2020 cycle there was significant difference between the 48kg and 52kg vs. 63kg, 70kg, 78kg ($p < 0.001$ for all comparisons) and +78kg ($p = 0.002$), and between the 57 kg vs. the others ($p < 0.001$ for all comparisons). The 48kg and 52kg categories spent more Golden Score time than others (48kg = 134.4 seconds and 52kg = 137.1 seconds vs. 63kg = 95.4 seconds; 70kg = 87.6 seconds; 78kg = 85.4 seconds, +78kg = 39 seconds), and the 57kg category spent more Golden Score time than the others (57kg = 137.1 seconds).

Regular time	2016							2020							
	48kg	52kg	57kg	63kg	70kg	78kg	+78kg	48kg	52kg	57kg	63kg	70kg	78kg	+78kg	
2016 (n=666)	48 kg		s	**	β	**	*	*	*	*	*	*	*	*	
	52 kg	s						ε	&&		ΩΩ	*	**	*	
	57kg	**							**		εε	*	#	**	
	63 kg	#						γ	ππ		#	*	*	*	
	70 kg	**										*	ββ	ππ	
	78 kg							*	**	*	ππ	*	*	*	*
	+78kg	*											*	s	s
2020 (n=666)	48 kg	*	ε	ε			**						#		
	52 kg	*	&&	**	ππ		*						ππ		
	57kg	*					ππ						*	&&	s
	63 kg	*	ΩΩ	εε	#		*						#		
	70 kg	*	*	*	*	*	*	#	ππ	*	#				
	78 kg	*	**	#	*	ββ	*	s			&&				
	+78kg	*	*	**	*	ππ	*	s			s				
Golden Score	2016							2020							
	48kg	52kg	57kg	63kg	70kg	78kg	+78kg	48kg	52kg	57kg	63kg	70kg	78kg	+78kg	
2016 (n=666)	48 kg		&	SS			&&	*	*	*	α				
	52 kg	&			SS			ββ	&&	*				γ	
	57kg	SS			ππ			*	**	*					
	63 kg		SS	ππ			&&	*	*	*	ππ				
	70 kg							*	*	*					
	78 kg							Ω	Ω	*					
	+78kg	&&			&&					*				π	
2020 (n=666)	48 kg	*	ββ	*	*	*	Ω			*	*	*	*	#	
	52 kg	*	&&	**	*	*	Ω			*	*	*	*	#	
	57kg	*	*	*	*	*	*	*	*		*	*	*	*	
	63 kg	π			ππ			*	*	*					
	70 kg							*	*	*					
	78 kg							*	*	*					
	+78kg		γ					#	#	*					

Fig. 1. Significant change in female judo combat time separated by the end time between 2016 and 2020 cycle), according weight divisions.

Significant difference: * $p < 0.001$; ** $p = 0.001$; # $p = 0.002$; ## $p = 0.005$; ∞ $p = 0.006$; Ω $p = 0.008$; ΩΩ $p = 0.009$; β $p = 0.011$; ββ $p = 0.012$; & $p = 0.013$; && $p = 0.014$; s $p = 0.015$; ss $p = 0.018$; ε $p = 0.019$; εε $p = 0.021$; π $p = 0.023$; ππ $p = 0.028$; πππ $p = 0.030$; ππππ $p = 0.033$; α $p = 0.034$; αα $p = 0.035$; @ $p = 0.039$; γ $p = 0.041$; γγ $p = 0.046$; ε $p = 0.049$.

Fig. 2 shows the proportion of combats between the 2016 and 2020 cycles that ended in Regular Time or Golden Score, as well as the distribution of the end of these combats per minute. There was a significant difference ($p < 0.001$) in both comparisons. In the 2020 cycle, there was an 11% increase in the occurrence of Golden Score compared to 2016. In the minute-by-minute analysis of the end of combats, there was a significant difference in Regular Time (the 2020 cycle had the lowest occurrence), and in the ≤ 1 min, ≤ 2 min, ≤ 3 min, $GS \leq 1$ min, $GS \leq 2$ min, $GS \leq 4$ min and $GS + 4$ min periods (the 2020 cycle had the highest occurrence of combats). In addition, in the 2016 cycle most combats (63%) ended in the last minute of regular time (< 4 min=31%; Regular time=32%); while in the 2020 cycle there was a 24% decreasing in the number of combats that ended in Regular time, an increase of 3.9% in the number of combats that exceeded the 4 minutes of the Golden Score, and a more balanced distribution of combats per period of closure.

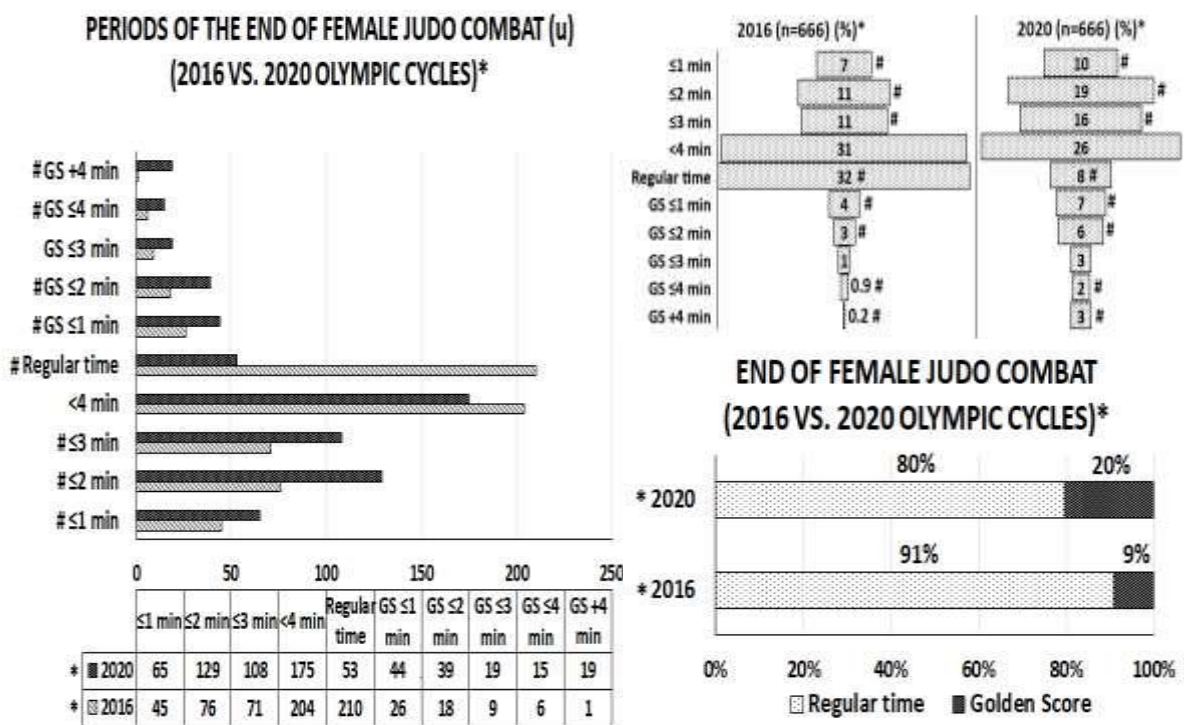


Fig. 2. Proportion of judo combats by time of ending in the 2016 and 2020 Olympic cycles (n=1332).

* $p < 0.001$: 2016 vs. 2020 end-of-combat period, and 2016 vs. 2020 end of combat; # $p < 0.05$ end of combat periods: 2016 vs.2020 in the ≤ 1 min, ≤ 2 min, ≤ 3 min, Regular time; $GS \leq 1$ min, $GS \leq 2$ min, $GS \leq 4$ min, $GS + 4$ min; GS – Golden Score; min – minute; u – unit.

Fig. 3 to 9 show the proportions of combats by end period in the 2016 and 2020 cycles in each weight division. There was a significant difference in the proportion of combats that ended in Regular Time or Golden Score for the 48kg ($p < 0.001$), 63kg ($p = 0.001$) and 78kg

($p < 0.001$), with an increase in the occurrence of Golden Score in the 2020 cycle (48kg = 18%, 63kg = 17% and 78kg = 21% increase compared to the 2016).

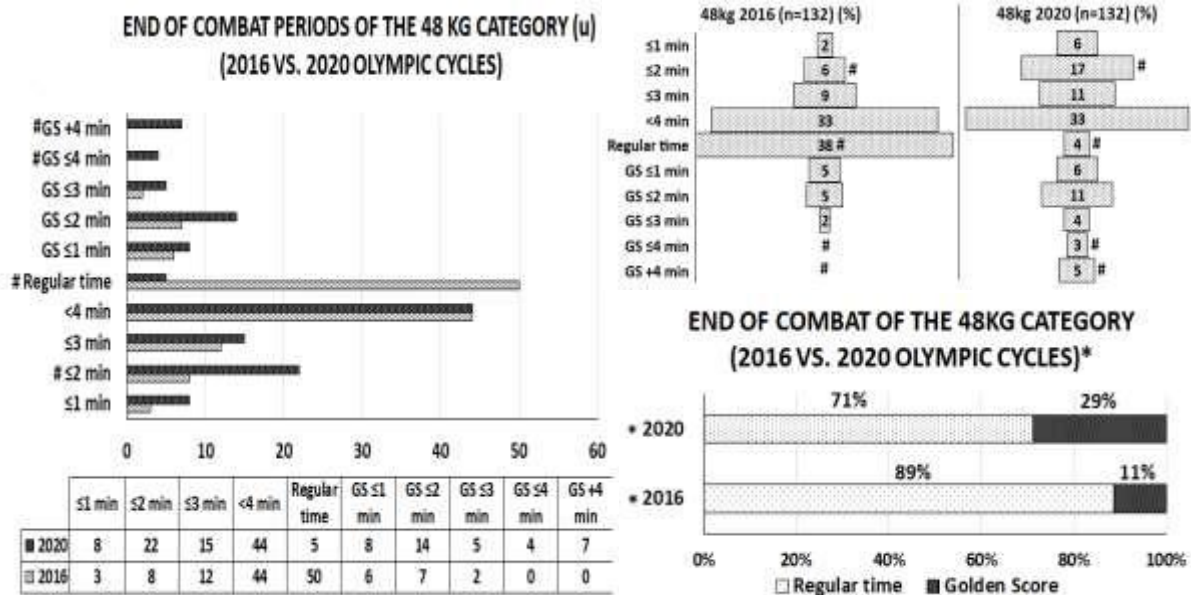


Fig. 3. Proportion of judo combats in the 48kg category by time of ending in the 2016 and 2020 Olympic cycles (n=264).

* $p < 0.001$: 2016 vs. 2020 end of combat; # $p < 0.05$ end of combat periods: 2016 vs.2020 in the ≤ 2 min, Regular time; GS ≤ 4 min, GS+4min; GS – Golden Score; min – minute; u – unit.

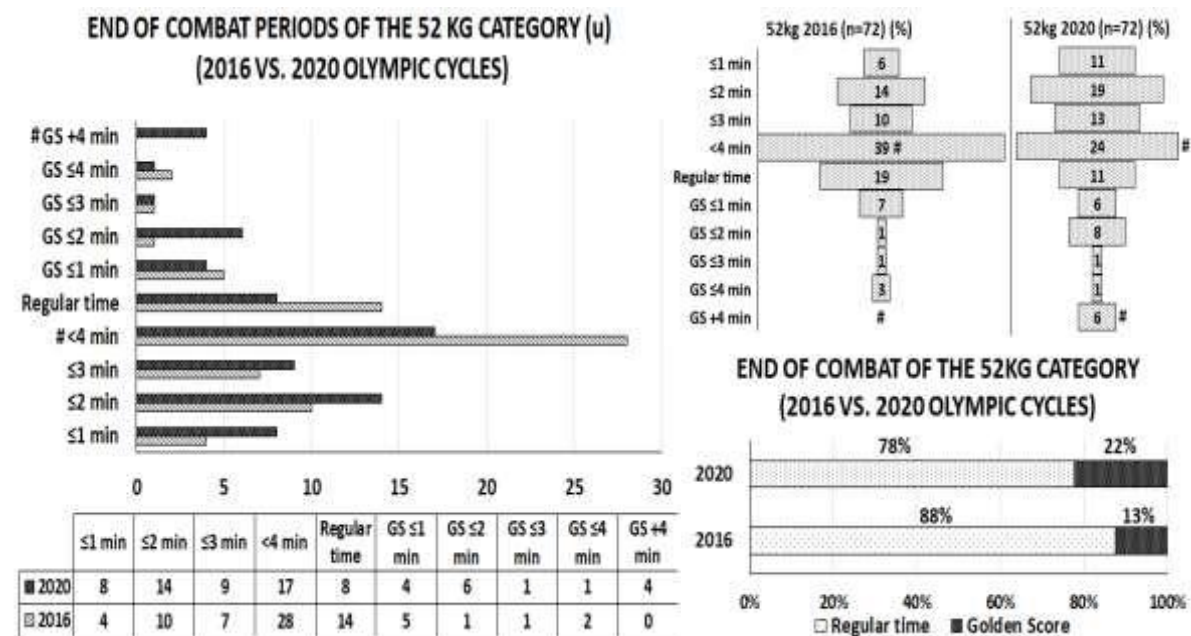


Fig. 4. Proportion of judo combats in the 52kg category by time of ending in the 2016 and 2020 Olympic cycles (n=144).

$p < 0.05$ end of combat periods: 2016 vs.2020 in the ≤ 4 min, GS+4min; GS – Golden Score; min – minute; u – unit.

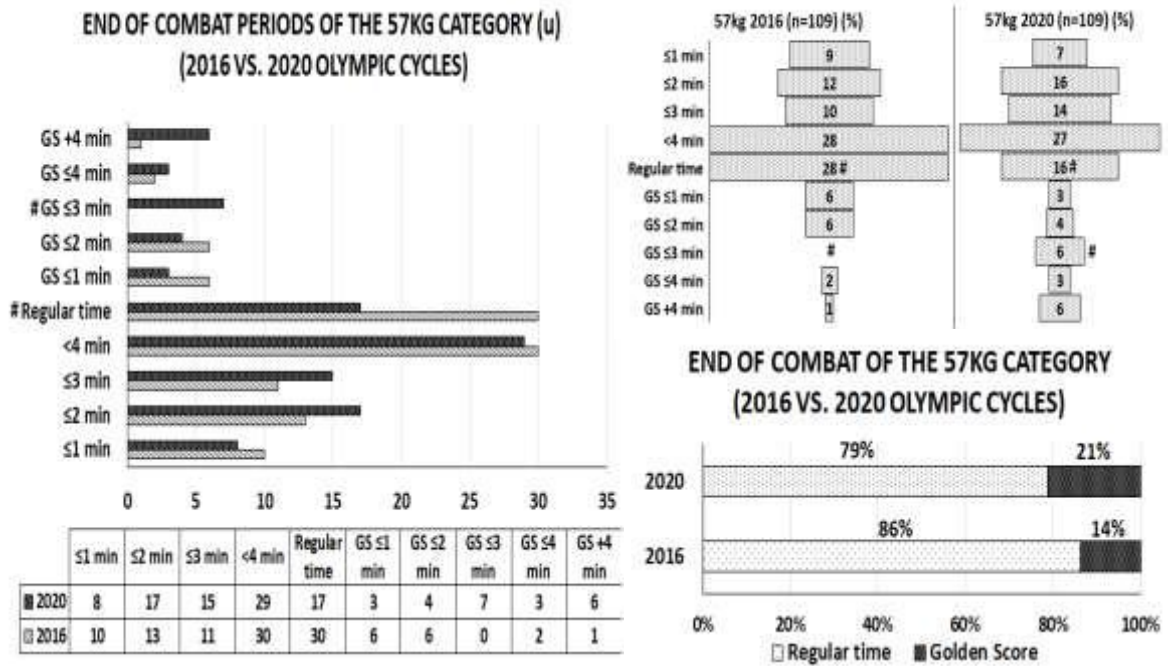


Fig. 5. Proportion of judo combats in the 57kg category by time of ending in the 2016 and 2020 Olympic cycles (n=218).

p<0.05 end of combat periods: 2016 vs.2020 in the Regular time, GS≤3min; GS – Golden Score; min – minute; u – unit.

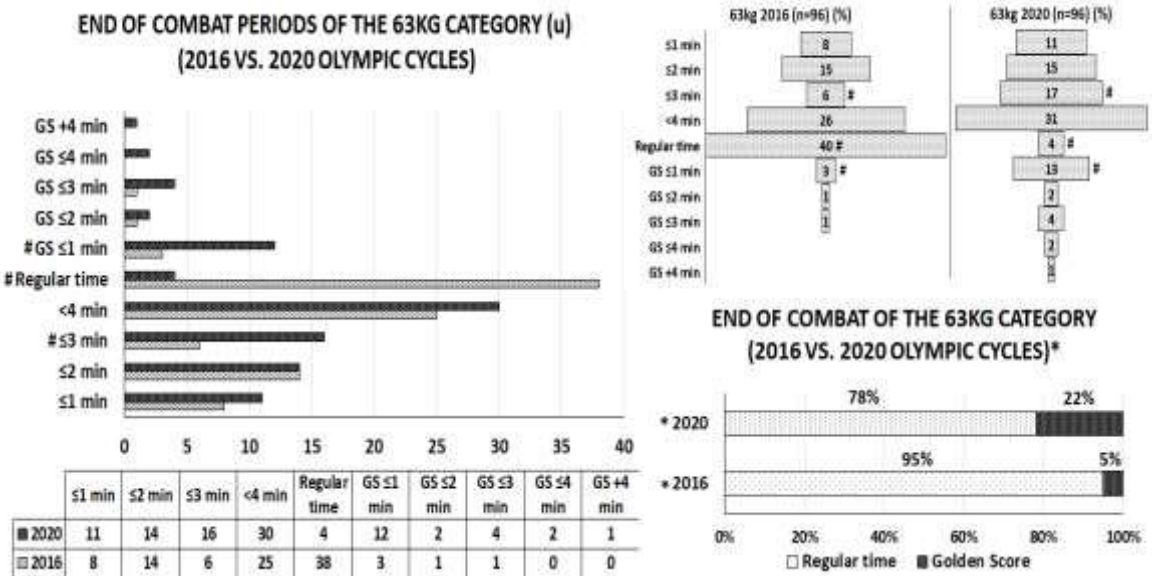


Fig. 6. Proportion of judo combats in the 63kg category by time of ending in the 2016 and 2020 Olympic cycles (n=192).

* p<0.001: 2016 vs. 2020 end of combat; # p<0.05 end of combat periods: 2016 vs.2020 in the ≤3min, Regular time; GS≤1min; GS – Golden Score; min – minute; u – unit.

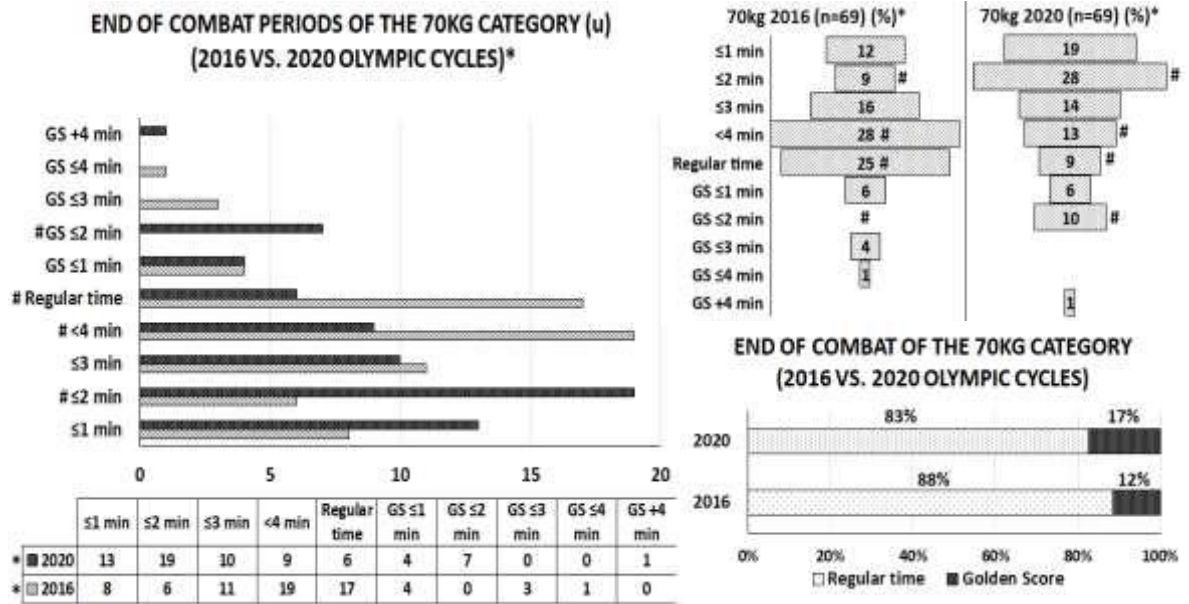


Fig. 7. Proportion of judo combats in the 70kg category by time of ending in the 2016 and 2020 Olympic cycles (n=138).

* p=0.024: 2016 vs. 2020 end-of-combat period; # p<0.05 end of combat periods: 2016 vs.2020 in the ≤2min, ≤4min, Regular time; GS≤2min; GS – Golden Score; min – minute; u – unit.

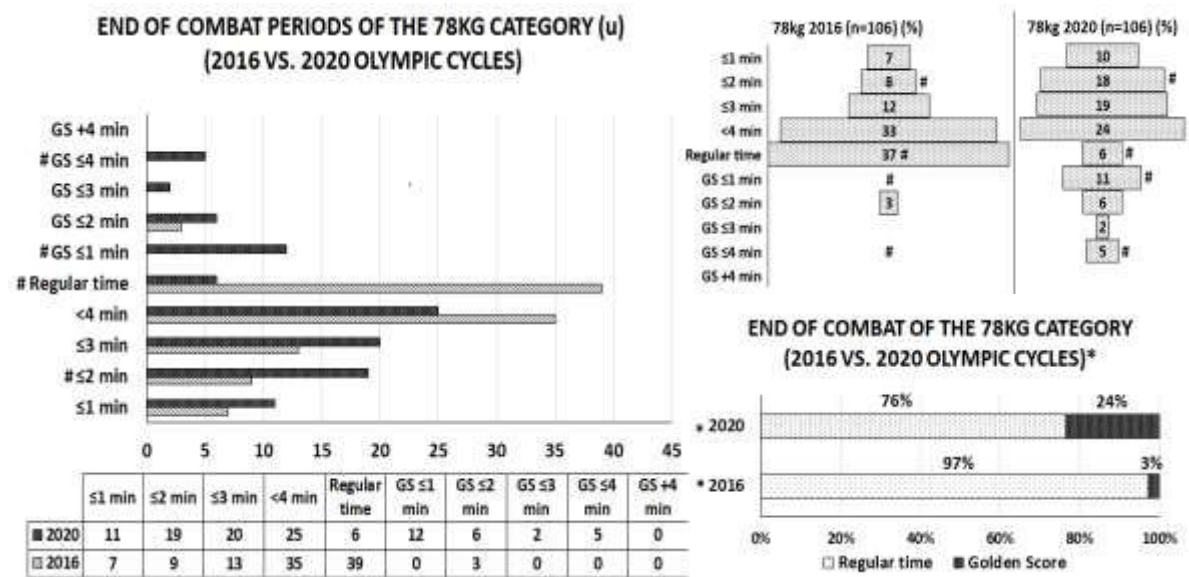


Fig. 8. Proportion of judo combats in the 78kg category by time of ending in the 2016 and 2020 Olympic cycles (n=212).

* p<0.001: 2016 vs. 2020 end of combat; # p<0.05 end of combat periods: 2016 vs.2020 in the ≤2min, Regular time; GS≤1min, GS≤4min; GS – Golden Score; min – minute; u – unit.

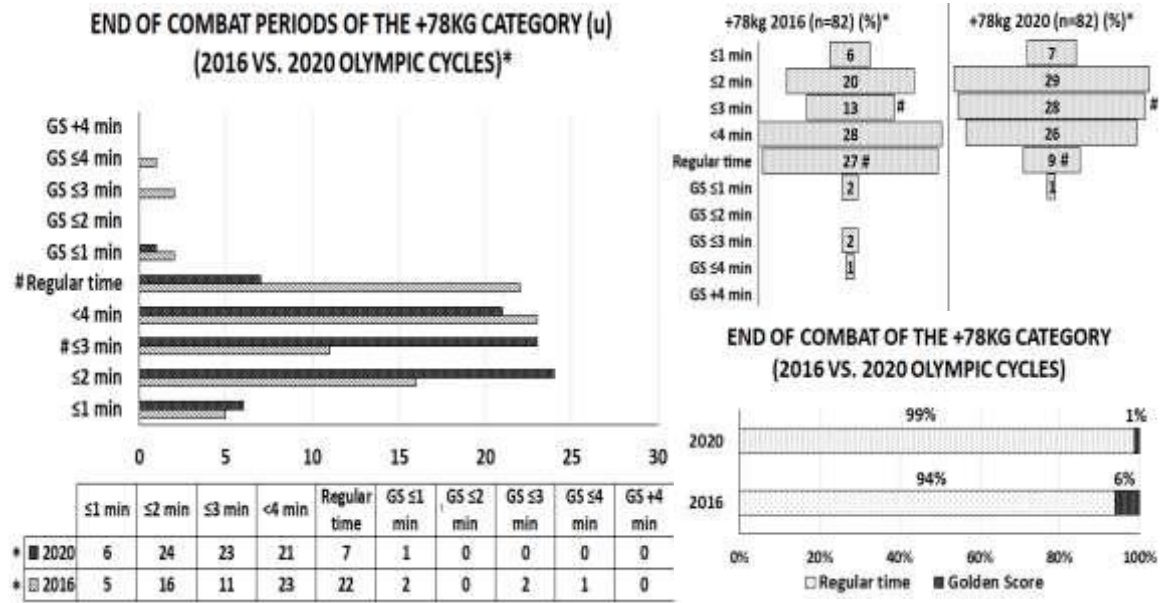


Fig. 9. Proportion of judo combats in the +78kg category by time of ending in the 2016 and 2020 Olympic cycles (n=164).

* p=0.001: 2016 vs. 2020 end-of-combat period; # p<0.05 end of combat periods: 2016 vs.2020 in the ≤3min, Regular time; GS – Golden Score; min – minute; u – unit.

Regarding the configuration of the end of the combats minute-by-minute, there was a significant difference for the 70kg (p=0.024) and +78kg (p=0.001) between 2016 vs. 2020. In the 70kg 37% of the combats ended until 3 minutes of the regular time in the 2016 cycle (1min = 12%, 2min = 9%, 3min = 16%), whereas in the 2020 cycle 61% of the combats ended in this period of time (1min = 19%, 2min = 28%, 3min = 14%). In the +78kg 67% of combats ended in less than 4 minutes of regular time in the 2016 cycle (1min = 6%, 2min = 20%, 3min = 13%, <4min = 28%), whereas in the 2020 cycle 90% of combats ended in this time period (1min = 7%, 2min = 29%, 3min = 28%, <4min = 26%) (Fig. 7 and 9).

In the isolated analysis of each minute of combat by weight division, we found a significant difference (p<0.05) that has been described below:

A) 48kg: in the 2020 cycle there was a 34% decrease in the number of combats ended in the Regular time; 11% increase in combats that ended in the ≤2min period; and an 8% occurrence of combats that ended after 3 minutes of the Golden Score (GS≤4min=3%, GS+4min=5%), since in the 2016 cycle all combats that required a Golden Score ended until 3 minutes of that period (Fig. 3). B) 52kg: in the 2020 cycle there was a 15% decrease in the number of combats ended in the <4min; and a 6% occurrence of combats that ended after 4 minutes of the Golden Score, since in the 2016 cycle all combats that required a Golden Score

ended until $GS \leq 4\text{min}$ period (Fig. 4). C) 57kg: in the 2020 cycle there was a 12% reduction in the number of combats ended in the Regular time; and a 6% occurrence of combats that ended in the $GS \leq 3\text{min}$ (Fig. 5). D) 63kg: in the 2020 cycle there was a 36% decrease in the number of combats ended in the Regular time; and an 11% increase in combats that ended in the $\leq 3\text{min}$ and 10% in those that ended in the $GS \leq 1\text{min}$ (Fig. 6). E) 70kg: in the 2020 cycle there was a 15% decrease in the number of combats that ended in the $< 4\text{min}$ and 16% in those that ended in the Regular time; in addition, there was an 19% increase in combats that ended in the $\leq 2\text{min}$ and a 10% occurrence in combats that ended in the $GS \leq 2\text{min}$ (Fig. 7). F) 78kg: in the 2020 cycle there was a 31% decrease in the number of combats that ended in the Regular time; an 10% increase in combats that ended in the $\leq 2\text{min}$ period; and a 11% occurrence in combats that ended in the $GS \leq 1\text{min}$ period and 5% in those that ended in the $GS \leq 4\text{min}$ period. It is important to highlight that in 2016 cycle only 3% of the combats required a Golden Score, and all of them ended in the $GS \leq 2\text{min}$ period (Fig. 8). G) +78kg: in the 2020 cycle there was a 18% decrease in the number of combats that ended in the Regular time; and an 15% increase in combats that ended in the $\leq 3\text{min}$ period. Only 1% of combats in the 2020 cycle required a Golden Score, and they all finished within 1 minute of this period (Fig. 9).

4. DISCUSSION

This study compared the female judo combat time in international competitions between the 2016 and 2020 Olympic cycles, verifying differences between the weight divisions. Important changes in female judo rules in 2013, 2015, 2017 and 2018 might have influenced the combat time in these Olympic cycles. Our main results showed that although there was no significant difference in the total combat time between cycles (Table 1), there was a significant difference when the analysis was done by combat end time (Table 2 and Fig. 2). Furthermore, when we analyzed the data, we found specific results for each division (Table 2; Fig. 1 to 9).

Regarding methods of analysis and limitations, the time-motion analysis of video-based systems is essential in judo, involves the quantification of efforts durations and results may increase the specificity of the strength and conditioning female program. Our study indicates the lack of specific findings associated with attack and gripping configurations as a limitation. For the time-motion analysis, the proximity between judo athletes and the unpredictability could increase the subjectivity of the analysis and make it susceptible to errors caused by the contexts. However, total combat time analysis demonstrated a great accuracy in intra and inter agreements, with $r \geq .99$ (31). Moreover, the quantification of

female combat demands is receiving increased consideration as requirement for a better understanding of the physiological and tactical profiles of judo weight categories (11,13,38,45).

For a more didactic approach to the results, we divided the discussion into the following subchapters: a) female combat time between 2016 and 2020 cycle (a general analysis) and; b) female combat time by weight division between 2016 and 2020 cycle.

4.1. Female combat time between 2016 and 2020 cycle

In the 2016 Olympic cycle, we found an average female judo combat time of 204.3 seconds. Disputes for the Gold Medal of female judo at the Rio de Janeiro 2016 Olympics had a combat average of 232.7 seconds (6). This value was higher than that of our study, probably due to the characteristics (finals) and the lower number of combats analyzed by them. In our study, we did not separate the types of combat (qualifications, repechage, semifinals and finals), we only guaranteed that the combats were for the top 20 athletes in the World Ranking in each category. In the 2020 cycle, we found an average combat time of 197.2 seconds (Table 1). Ceylan and Balci (10), who analyzed 665 female combats of elite athletes in the 2018 and 2019 World Championships, found an average combat time of 180.7 seconds, which is lower than ours results.

When comparing the mean combat time between the 2016 and 2020 cycles, we found no significant difference. Initially, it was thought that there really was no difference between the groups, however, when the combats were analyzed by the time they ended, we found significant differences. In the 2020 cycle, the time spent in combats that ended in Regular Time was less and the time spent in combats that required Golden Score was higher than in the 2016 cycle. This change in time between Olympic cycles can be explained by the change in judo rules. In the 2016 Olympic cycle, although punishments were no longer worth points (21), they were still useful to decide the winner of combats, as the athlete with the most punishments would lose the tied combat as soon as the regular time ended. Furthermore, as the Golden Score time became unlimited (21) and the normal combat time was reduced to 4 minutes (22), winning in regular time became extremely important to avoid the Golden Score. Therefore, making the opponent suffer punishments and managing the combat until the regular time runs out, became a good strategy for athletes who could not define the combat through attacks. This explains why 91% of the combats from the 2016 cycle ended in regular time.

On the other hand, in the 2020 cycle, *Yuko* was extinguished and punishments no longer decided the winner of the combat (23,24), so attack became the main option to obtain victory, and this should be done as quickly as possible to avoid the Golden Score. Thus, the time of combats that ended in regular time was reduced in 2020, compared to 2016. However, as only a disqualification or a score could decide the winner on the Golden Score, athletes who failed to score in regular time continued with this difficulty in overtime. Thus, many combats took a long time to be defined, depending on the physical wear of the athletes, and increasing the time of combats that ended in the Golden Score in the 2020 cycle, compared to 2016.

That is why we found a significant difference in the proportion of combats in relation to the end period from minute to minute between cycles. In the 2020 cycle, there was an 11% increase in the occurrence of the Golden Score and a more balanced distribution of combats by closure period compared to 2016 cycle. In addition, in 2020 cycle there was an increase of 3.9% in the number of combats that exceeded the 4 minutes of the Golden Score. On the other hand, in the 2016 cycle 63% of the combats finished in the last minute of regular time. As far as we know, there are no previous studies that have made this type of comparison in the female judo combat time, separating the combats by the moment they ended. This type of analysis is important to identify what happens in judo combats. Therefore, we also believe that an analysis of combat time in each weight division is necessary so that we can target training to the specific needs of each of them.

4.2. Female combat time by weight division between 2016 and 2020 cycle

Our data suggest that the +78kg category differed from the other categories, because in the 2020 cycle there was a reduction in the time and the occurrence of the Golden Score ($\leq 5\%$) compared to the 2016 cycle, besides having had more than 90% of the combats finished within the regular time in both the 2016 and 2020 cycles (Fig. 9). In the Ceylan and Balci (10) study, which analyzed combats from 2018 to 2019, although they did not find significant differences in the combat time between the weight divisions, they observed that 5 of the 6 combats in the +78kg category ended with *Ippon* before the end of the regular time. Furthermore, another fact that stands out is that the +78kg category behaved in a totally different way from the 78kg category. This observation is important because, in training, these two categories tend to have similar training because they are the heaviest. However, data from our study showed that they had different time requirements and they also behaved differently in the face of rule changes. Within the 2016 cycle, the +78kg category spent a

lower regular combat time than the 78kg category. Moreover, in the 2020 cycle, there was a significant increase in the occurrence of Golden Score for the 78kg category (21% increase).

This increase drew attention, considering that in the 2016 cycle the lowest occurrence of Golden Score was in the 78kg category (3%) and the highest in the 57kg category (14%); while in the 2020 cycle, the lowest occurrence of Golden Score was in the +78kg category (1%) and the highest in the 48kg category (29%) followed by the 78kg category (24%). In addition, in the 2016 cycle, the 78kg category had all Golden Score combats ended up before 3 minutes, whereas in the 2020 cycle, 7% of its exceeded 3 minutes of the Golden Score time. These data confirm that during the planning of training the 78kg category should not be grouped with the +78kg category, as they demand different efforts during combat. However, divergent data were observed in 2018-2019 combats, in which the lowest occurrence of the Golden Score was in the 48kg category and the highest was in the 57kg category (10). We believe that it might be due to the characteristic of the competition analyzed. Although the other weight divisions did not show significant differences in the analysis of the total combat time, when we analyzed by separating the combats that ended until regular time from those that ended in the Golden Score, we observed that in the 2020 cycle there was significantly less time spent in combats that ended until regular time for almost all categories (except 57kg category). However, the data showed that the lighter categories tend to spend more combat time than the heavier ones.

The data of the golden score show that in the 2020 cycle the lighter categories have tried to define combat as quickly as possible, hence the reduction in regular time; however, when they failed to do so, they were unlikely to settle the Golden Score winner quickly. This can be seen in Fig. 3 to 6, which show an increase in combats that exceeded the 3 minutes of the Golden Score for these categories in the 2020 cycle compared to the 2016 cycle. As from 2017 the use of opponent's punishment to win a combat became less effective, the lighter categories had difficulty in defining the combat winner within the regular time.

The variation in temporality amongst the weight divisions and Olympic cycles may be the result of two causes: 1) inequality of physical fitness, considering judo rules and 2) the tactical response to the rules changes, as being penalized, which has shown to be a factor in the competitive outcome of female judo combats, particularly in heavyweight athletes (45). Despite differences in the female combat time of judo competition between weight categories, normative values for judo-specific fitness have been limited to female athletes and competitive level distinctions (2,28). With limited data available on the combat demands across weight categories in judo, the present research results provide information regarding

the unique distribution of combat time by weight categories in elite female athletes during international competition. This study highlights the need to consider both the accumulated and individual combat time during time-motion analysis. While accumulated combat time and the duration of individual combat actions tended to be similar between men and women in corresponding weight categories (11,13,38), the present study demonstrated differences in combat time among weight categories during both Olympic cycles. Thus, interpretation of weight-category-specific combat time data likely differs according to the combat actions associated with each change rules (37).

5. PRACTICAL APPLICATIONS

Although there is no significant difference in the total combat time between the Olympic cycles (2016 vs. 2020), when the combats are analyzed by the moment when they ended, a significant difference was found both in the total sample and by weight divisions. To summarize and facilitate the practical application of the temporal combat action data found in this study in the training prescription, we made a table (Table 3) that shows the significant changes between the 2020 and 2016 cycle in each weight division.

Table 3. Significant change ($p \leq 0.05$) in female judo in the 2020 Olympic cycle compared to the 2016 cycle, according weight divisions.

Weight divisions	Total combat time	Combat time		Occurrence ratio	
		Regular time	Golden Score	Regular time	Golden Score
48 kg	--	↓	↑	↓	↑
52 kg	--	↓	↑	--	--
57kg	--	--	↑	--	--
63 kg	--	↓	↑	↓	↑
70 kg	--	↓	--	--	--
78 kg	--	↓	--	↓	↑
+78kg	--	↓	↓	--	--

-- kept the average combat time; ↑ increased the average combat time; ↓ decreased the average combat time.

Thus, in the 2020 cycle: A) The 48kg and 63kg had: a decrease in the time and proportion of combats that ended until regular time; an increase in the time and proportion of combat that ended up in the Golden Score; B) The 52kg had: a decrease in the time of combats that ended until regular time; an increase in the time of combat that ended up in the Golden Score; C) The 57kg had an increase in the time of combats that ended in the Golden Score; D) The 70kg had a decrease in the time of combats that ended until regular time; E) The 78kg had: a decrease in the time and proportion of combats that ended until regular time; an increase in the proportion of combat that ended up in the Golden Score; F) The +78kg had a decrease in the time of both combats that ended until regular time and in the Golden Score;

Thus, this data showed that in the 2020 cycle there was a decrease in the time spent in combats that ended until regular time for almost all divisions (except 57kg), and an increase in the Golden Score combat time for the lighter weights (48kg, 52kg, 57kg and 63kg). In addition, the +78kg behaved differently from the others, with less combat time and a lower occurrence and time spent in the Golden Score. In addition, it is suggested not to group the training of the 78kg and +78kg, as in the 2020 cycle the 78kg had a higher Golden Score occurrence than the +78kg, which reflects on the energy demand required for each division. These data should be taken into account in the prescription of female judo training, for a more specific adaptation of the workload.

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AUTHORS' CONTRIBUTIONS

LBMB participated in the research concept and study design, literature review, data collection, data analysis and interpretation, statistical analyses and writing of the manuscript; EAAM, BM and CJB participated in the research concept and study design, data analysis and interpretation, statistical analyses and writing of the manuscript.

CONFLICT OF INTERESTS

The authors declare no conflict of interests

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6.3 ANÁLISE DO TEMPO DAS FASES DO COMBATE MASCULINO E DA RELAÇÃO ESFORÇO-PAUSA POR DIVISÃO DE PESO E MOMENTO DE TÉRMINO ENTRE CICLOS OLÍMPICOS 2016 VERSUS 2020

Combat Time Phases of Male Judo between 2016 and 2020 Olympic Cycles

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Abstract

This study compared the time of combat phases of male judo in international competitions between the 2016 and 2020 Olympic cycles, verifying differences between weight divisions. 1380 combat videos of male judo from two Olympic cycles (2016=690; 2020=690) of the top 20 in the world rankings by weight divisions were analyzed. Our main results showed that athletes from the 2020 cycle spent less time in the gripping, attack, defense and groundwork phases, and more time in the pause phase than in the 2016 cycle ($p \leq 0.001$), resulting in a smaller effort/pause ratio in the 2020 cycle (2020=2.3:1 vs. 2016=3.1:1). In addition, in the 2020 cycle, the approach phase became more relevant for athletes from 66kg and 90kg; all weight divisions reduced gripping time in combats that ended up to Regular Time; the 90 and 100kg athletes also needed less gripping time in *Golden Score* combats; the 60, 66, 81 and 100kg had their combat temporal behaviors modified (almost all combat phases had reduced time); the >100kg showed the greatest change in the effort/pause ratio between the Olympic cycles. These data must be taken into account to prescribe specialized male judo training.

Keywords: martial arts; combat sports; performance; Golden Score; temporal behavior.

1. Introduction

The judo combat can be divided into temporal phases, such as approach, gripping, attack, defense, groundwork and pause (Miarka, 2014; Miarka, Branco, Vecchio, Camey, & Franchini, 2015; Miarka, Hayashida, Julio, Calmet, & Franchini, 2011). Studies on the analysis of time-motion in judo have been used to describe the technical and tactical behavior of athletes and to characterize the phases of the combat to predict performance (Barreto, 2019; Díaz-de-Durana, 2018; Soriano *et al.*, 2019). It is advisable to know the data of each phase of

the athlete's combat, in order to create a more specific judo training (Segedi, Sertić, Franjić, Kuštro, & Rožac, 2014; Sterkowicz-Przybycień, Miarka, & Fukuda, 2017).

However, judo rule changes, which usually occur with each new Olympic cycle, can influence fighting patterns in different ways and they would change the time spent in these combat phases. As an example in 2017, the International Judo Federation (IJF) changed the combat time of male judo from 5 to 4 minutes (IJF, 2017a). Furthermore, as of 2017, Yuko was extinct and penalties lost their relevance in the decision of the combat winner (IJF, 2017a, 2017b). Therefore, understanding how these rule changes influence the temporal phases of judo combat in different weight divisions is necessary for contextualized planning according to competitive standards.

Therefore, the objective of this study was to identify and analyze how the temporal phases of international male judo combats have behaved in two Olympic cycles (2016 and 2020), by weight division, with different rule configurations. This information can be useful for judo coaches to plan judo training in view of the new temporal configuration of the judo combat phases.

2. Methods

2.1. Sample

In this study, 1380 combat videos of male judo from two Olympic cycles (2016 and 2020) were analyzed, which were distributed in identical amounts per Olympic cycle and by weight division (60kg=123; 66kg=91; 73kg=100; 81kg=102; 90kg=94; 100kg=89; >100kg=91; total=690 combats/ cycle). The videos were of combats from athletes who were ranked in the top 20 of each weight division in the World Ranking (International Judo Federation - ranking of May 30, 2016 and March 16, 2020). In addition, the videos were obtained from the virtual channel of the International Judo Federation. They had quality for analysis (standard 480/60i) and a panoramic view of the entire competition area.

The competitions analyzed took place in 2015, 2016, 2019 and 2020, before being interrupted due to the COVID-19 pandemic. They were from the following international competitions: 28 Grand Prix (Almaty 2016; Antalaya 2019; Budapest 2016, 2019; Dusseldorf 2015, 2016; Havana 2016; Hohhot 2019; Jeju 2015; Marrakech 2019; Montreal 2019; Qingdao 2015, 2016; Samsun 2015, 2016; Tashkent 2015, 2016, 2019; Tbilisi 2015, 2016, 2019; Tel Aviv 2019, 2020; Ulaanbaatar 2015, 2016; Zagreb 2015, 2016, 2019); 12 Grand Slam (Abu Dhabi 2016, 2019; Baku 2016, 2019; Brasília 2019; Dusseldorf 2019; Paris 2015,

2016; Tokyo 2015, 2016; Tyumen 2015, 2016); 2 World Championships (Astana 2015; Tokyo 2019); and the Rio 2016 Olympic Games.

2.2. Procedures

To analyze the videos, we used an analysis protocol validated for judo combats, the Frami® software and VLC media player 3.0.4 (Miarka, 2014; Miarka *et al.*, 2015; Miarka *et al.*, 2011). This judo analysis protocol has objectivity when analyzed by experts with at least a brown degree (1st Kyu) (Ando, Miarka, & Pinto, 2016). In this study, the videos were analyzed by an expert with more than 25 years of judo practice, black graduation (2nd Dan), who performed a 12-hour training to familiarize with the buttons and commands of Frami® and the protocol of analysis. The reliability of the expert analysis was verified (20 judo combats reanalyzed 1 week later) and it had an “excellent” agreement for combat time (intraclass correlation coefficient=0.99; confidence interval=0.99; 1).

According to the current rule in each Olympic cycle analyzed, the combats had a regular time of 5 minutes in the 2016 cycle (IJF, 2013) and 4 minutes in the 2020 cycle (IJF, 2017a). In this study, the time spent in each combat phase established by the analysis protocol (Miarka, 2014; Miarka *et al.*, 2015; Miarka *et al.*, 2011) was verified by weight division and by Olympic cycle. The combat phases analyzed were: approach, gripping, attack/defense, groundwork and pause. The time of each combat phase was also verified by separating the combats between those that ended until Regular Time (RT) and those that ended in *Golden Score* (GS). In addition, we calculate the effort/pause ratio by dividing the sum of time spent in combat action phases (approach, gripping, attack/defense and groundwork) by the pause time.

2.3. Statistical Analysis

We used the SPSS software (version 20.0; SPSS, Inc., Chicago, IL, USA), with a significance level of $p \leq 0.05$, for the statistical analysis. The reliability of the expert analysis was verified by the Intraclass Correlation Coefficient test. The time data for each phase of the judo combat were presented in seconds as mean, standard deviation and interval. In the analysis of data by Olympic cycle, Student's t test for independent samples was used. In the weight division analysis, ANOVA for independent factors was used.

3. Results

The time data in each combat phase of male judo by Olympic cycle (2016 x 2020) and by weight division are described in Table 1. In the 2020 cycle, athletes spent less time in the action phases (gripping, attack, defense and groundwork) and more time in the pause phase, compared to the 2016 cycle ($p < 0.001$). Therefore, the effort/pause ratio in the 2020 cycle was lower compared to the 2016 cycle (2020=2.3: 1 vs. 2016=3.1: 1).

In the analysis by weight division there was a significant difference in the time of the combat phases between the Olympic cycles in: a) gripping phase: the 90kg ($p=0.004$) and >100kg ($p=0.009$) spent less time in the 2020 cycle than in the 2016 cycle; b) attack, defense and groundwork phases: the 66kg ($p=0.013$, $p=0.012$ and $p < 0.001$ respectively) and 81kg ($p < 0.001$, $p=0.004$ and $p=0.001$ respectively) spent less time in the the 2020 cycle than in the 2016 cycle. In addition, there was a reduction in the effort/pause ratio in the 2020 cycle compared to the 2016 cycle for all weight divisions. In the 2016 cycle, the lowest effort/pause ratio was in the 60kg (3:1) and the highest in the >100kg (3.7:1). In the 2020 cycle, the lowest value was in the 90kg (2.1:1) and the highest value in the 73kg (2.6:1) (Table 1).

Figure 1 shows the significant difference when comparing the data in Table 1 between the weight divisions in each Olympic cycle. In the approach phase, within the 2020 cycle, there was a difference between the following weight divisions: the 81kg spent less time than 60 and 66kg ($p=0.012$ and $p < 0.001$ respectively); the 100kg spent less time than 66kg ($p=0.001$); the >100kg spent less time than 60, 66, 73 and 90kg ($p < 0.001$). In addition, between cycles the 60kg (2020) spent more approach time than 100kg (2016); and the >100kg (2020) spent less time than 60, 66, 73, 81 and 90kg from the 2016 cycle ($p < 0.05$) (Table 1; Fig. 1).

Regarding gripping phase, in the 2016 cycle there were the following significant differences: the 90kg spent more time than 60kg ($p=0.004$); the >100kg spent more time than 60 and 66kg ($p \leq 0.001$ for both) and 73kg ($p=0.001$). In the 2020 cycle, the 100kg spent more gripping time than 60kg ($p=0.013$); the >100kg spent more time than 60kg ($p=0.001$) and 66kg ($p=0.006$). Between cycles, the 60 and 66kg (2020) spent less time than 73, 81, 90 and 100kg from the 2016 cycle; the 73kg (2020) spent less time than 81, 90 and 100kg from the 2016 cycle; the 81kg (2020) spent less time than the 90kg (2016); the 90kg (2020) spent less time than 81 and 90kg (2016); the >100kg (2016) spent more time than all weight divisions from the 2020 cycle ($p \leq 0.05$) (Table 1; Fig. 1).

Table 1: Time of combat phases of male judo in the 2016 and 2020 Olympic cycles (n=1380)

Weight divisions (combats per cycle)	Combat phases time (seconds) (mean ± standard deviation/ interval)						Effort/pause ratio	
	Approach	Gripping	Attack	Defense	Groundwork	Pause		
All categories (n=690)	83.6±42.2/ 247	101.3±54.2/ 272 *	5.1±4.8/ 35 *	4.7±4.7/ 36 *	41.5±30.5/ 282 *	75.8±55.6/ 522 *	3.1: 1	
2016 cycle	60 kg (n=123)	89±40.6/ 220	88.6±48.1/ 191	5.5±4.9/ 26	4.4±5.1/ 24	46.2±28.3/ 130	77.6±46.3/ 239	3: 1
	66 kg (n=91)	82.5±38.7/ 244	92.9±44.9/ 177	6.7±6.1/ 30 \$	6.2±6.8/ 36 £	61.2±43.1/ 282 *	79.8±48/ 224	3.1: 1
	73kg (n=100)	88.3±47.6/ 214	96.6±52.4/ 221	4.5±3.7/ 24	4.2±3.4/ 16	34.5±26.6/ 112	71.4±64.1/ 522	3.2: 1
	81 kg (n=102)	87.9±41.2/ 167	111.2±49.2/ 238	6.3±5.5/ 29 *	5.8±5/ 25 €	45.6±27.2/ 141 #	83±47.7/ 275	3.1: 1
	90 kg (n=94)	84.6±38.5/ 182	117.6±54.8/ 240 #	5.1±5.1/ 35	3.9±4/ 22	41.6±27.1/ 105	81.9±78.1/ 450	3.1: 1
	100 kg (n=89)	72.4±37.9/ 169	105.8±55.9/ 239	4.7±3.7/ 23	4±3.7/ 15	38.1±24.1/ 110	71.7±56.7/ 324	3.1: 1
	>100kg (n=91)	77.3±48.1/ 224	130.6±63.4/ 271 &	3.1±3.2/ 17	3.1±3.2/ 16	21.8±18.2/ 74	63.7±40.5/ 181	3.7: 1
All categories (n=690)	82.2±52.9/ 369	83.3±51.5/ 325 *	4±3.3/ 24 *	3.7±3.7/ 29 *	33.7±27.6/ 253 *	89.9±79.9/ 584 *	2.3: 1	
2020 cycle	60 kg (n=123)	93.6±56.6/ 361	68.6±45.2/ 189	4.1±3.3/ 19	4.3±4.1/ 29	43.5±37.3/ 253	86.8±75.9/ 507	2.5: 1
	66 kg (n=91)	105.3±58/ 264	70.3±41.4/ 166	4.4±3.4/ 13 \$	3.8±3.6/ 15 £	39.8±26.6/ 131 *	96.1±88.8/ 505	2.3: 1
	73kg (n=100)	88.8±61.6/ 287	79.7±42.4/ 183	4.1±3.4/ 18	3.7±3.8/ 22	36.6±29.7/ 132	82.7±72.6/ 462	2.6: 1
	81 kg (n=102)	69.6±41.3/ 189	88.8±56/ 320	3.5±3.3/ 15 *	3.4±3.1/ 16 €	28.4±20.4/ 84 #	87.4±73.2/ 477	2.2: 1
	90 kg (n=94)	88.3±48.3/ 204	84±50.5/ 285 #	4.2±3.1/ 12	4.2±3.7/ 18	35.9±24.2/ 112	101.6±89.6/ 584	2.1: 1
	100 kg (n=89)	73.7±49.5/ 265	95.9±55/ 197	4.1±3.2/ 14	3.6±3.4/ 12	28.5±21/ 88	93.8±77.9/ 451	2.2: 1
	>100kg (n=91)	54.6±31.8/ 133	100.8±61.2/ 256 &	3.7±3.7/ 24	3±3.7/ 24	20.1±18.2/ 85	82.4±82.3/ 369	2.2: 1

Significant difference between 2016 vs. 2020 cycle: *p<0.001; #p=0.001; €p=0.004; &p=0.009; £p=0.012; \$p=0.013;

Combat phases/ cycle/ weight division	2016							2020							
	60kg	66kg	73kg	81kg	90kg	100kg	+100kg	60kg	66kg	73kg	81kg	90kg	100kg	+100kg	
Approach	2016 (n=690)														
	60 kg													*	
	66 kg													##	
	73kg													*	
	81 kg													*	
	90 kg													**	
	100 kg														
	+100 kg							*							
	2020 (n=690)														
	60 kg											ββ			*
	66 kg						*	##				*		**	*
	73kg														*
	81 kg								ββ	*					*
	90 kg														*
100 kg							**								
+100 kg	*	##	*	*	**		*	*	*	*		*			
Grapple	2016 (n=690)														
	60 kg				#									*	
	66 kg						*							*	
	73kg						**	##	π						
	81 kg				*	*	*	**				ε		*	
	90 kg	#						*	*	*	S	**		*	
	100 kg							*	*	εε				**	
	+100 kg	*	*	**				*	*	*	*	*	**	S	
	2020 (n=690)														
	60 kg			##	*	*	*	*					&	**	
	66 kg			π	*	*	*	*						Ω	
	73kg				**	*	εε	*						*	
	81 kg					S		*						*	
	90 kg				ε	**		*						*	
100 kg							**	&					*		
+100 kg						S	**	Ω					*		
Defense	2016 (n=690)														
	60 kg													∞	
	66 kg													*	
	73kg													ββ	
	81 kg													€	
	90 kg												**	*	
	100 kg														
	+100 kg	∞	*					**							
	2020 (n=690)														
	60 kg														
	66 kg														
	73kg														
	81 kg														
	90 kg														
100 kg															
+100 kg	∞	*					**								
Groundwork	2016 (n=690)														
	60 kg													*	
	66 kg	α			*	α	*	*	*	*	*	*	*	*	
	73kg													€€	
	81 kg											**		π	
	90 kg													*	
	100 kg											ΩΩ		**	
	+100 kg	*	*		*	*	ΩΩ		*	**	∞∞		ε	*	
	2020 (n=690)														
	60 kg												#	SS	
	66 kg													*	
	73kg										∞∞∞			#	
	81 kg	*	*			**						#			
	90 kg	*	*									ε		SS	
100 kg	*	*			μ						SS		*		
+100 kg	*	*	€€	*	*	**				*	*	#	SS		
Attack	2016 (n=690)														
	60 kg														
	66 kg							*	**	&	**	*	μ	*	
	73kg			∞											
	81 kg						*	Ω		β	*	γ	€€	**	
	90 kg														
	100 kg														
	+100 kg	μ	*			*									
	2020 (n=690)														
	60 kg														
	66 kg													Ω	
	73kg														
	81 kg	ππ	*			*									
	90 kg		#			γ									
100 kg		μ			€€										
+100 kg		*			**										
Passive	2016 (n=690)														
	60 kg														
	66 kg														
	73kg														
	81 kg														
	90 kg														
	100 kg														
	+100 kg														
	2020 (n=690)														
	60 kg														
	66 kg														
	73kg														
	81 kg														
	90 kg														
100 kg															
+100 kg															

Fig. 1. Significant changes in the time of combat phases of male judo between categories in the 2016 and 2020 Olympic cycle.
 Significant difference: *p<0.001; **p=0.001; μp=0.002; μμp=0.003; #p=0.004; ##p=0.005; Ωp=0.006; ΩΩp=0.007; αp=0.008; \$p=0.009; SSp=0.01; βp=0.011; ββp=0.012; &p=0.013; &&p=0.017; ∞p=0.019; ∞∞p=0.02; €p=0.021; €€p=0.025; €p=0.028; €€p=0.03; γp=0.031; γγp=0.037; πp=0.041; ππp=0.045; εp=0.049; εεp=0.05.

In the attack phase, in the 2016 cycle there were significant differences ($p \leq 0.05$) between: the 73kg spent less time than 66kg; the >100kg spent less time than 60, 66 and 81kg. Between cycles, the 60kg (2016) spent more attack time than 81kg (2020); the 66kg (2016) spent more time than all weight divisions from the 2020 cycle; the 81kg (2016) spent more time than all weight divisions from the 2020 cycle, except the 66kg ($p \leq 0.05$). Regarding defense phase, in the 2016 cycle there were significant differences ($p \leq 0.05$) between: the 66kg spent more time than 90 and 100kg; the >100kg spent less time than 60, 66 and 81kg. Between cycles, the 60kg (2016) spent more time than >100kg (2020); the 66kg (2016) spent more time than 66, 81, 100 and >100kg from the 2020 cycle; the 81kg (2016) spent more time than 73, 81, 100 and >100kg from the 2020 cycle ($p \leq 0.05$) (Table 1; Fig. 1).

In the groundwork phase, in the 2016 cycle there were significant differences ($p \leq 0.05$) between: the 66kg spent more time than all weight divisions; the >100kg spent less time than all weight divisions, except 73kg. In the 2020 cycle there were significant differences ($p \leq 0.05$) between: the 60kg spent more groundwork time than 81 and 100kg; the >100kg spent less time than 60, 66, 73 and 90kg. Between cycles, the 66kg (2016) spent more groundwork time than all 2020 weight divisions, except >100kg (2020); the >100kg (2016) spent less time than 60, 66, 73 and 90kg from 2020 cycle; both 81 and 100kg (2020) spent less time than 60 and 81kg (2016); the >100kg (2020) spent less time than all 2016 weight divisions, except >100kg (2016) ($p \leq 0.05$). Regarding pause phase, between cycles the 90kg (2020) spent more time than the >100kg (2016) ($p = 0.017$) (Table 1; Fig. 1).

Table 2 describes the time of the combat phases that ended in RT or GS in each Olympic cycle (2016 x 2020) and by weight division. In the combats that ended in the RT, the 2020 athletes spent less time in all combat phases compared to the 2016 athletes ($p < 0.05$). In the combats that ended in the GS, the 2020 athletes spent less time in the gripping, attack, defense and groundwork phases, and more time in the pause phase compared to the 2016 athletes ($p < 0.05$). The effort/pause ratio reduced in the 2020 cycle, compared to the 2016 cycle, both in combats that ended in RT (2020=2.6:1 vs. 2016=3.2:1) and in combats that ended in the GS (2020=2:1 vs. 2016=2.6:1) (Table 2).

In the analysis by weight division, in the 2020 cycle compared to the 2016 cycle, there was a significant difference ($p < 0.05$) in the following combat phases (Table 2): Combats that ended in RT: the 60kg spent less time in all combat phases; the 66kg spent less time in the gripping, attack, defense and groundwork phases; the 73kg spent less time in the approach, gripping and defense phases; the 81 and 100kg spent less time in the approach, gripping, defense and groundwork phases; the 90 and >100kg spent less time in the approach and

gripping phases. In addition, there was a reduction in the effort/pause ratio in the 2020 cycle compared to the 2016 cycle for all weight divisions.

Combats that ended in the GS: the 60kg spent less time in the attack and defense phases; the 66 and 81kg spent less time in the attack, defense and groundwork phases; the 90kg spent less time in the approach, gripping and attack phases; the 100kg spent less time in the gripping phase; the >100kg spent more time in the pause phase. In addition, there was a reduction in the effort/pause ratio in the 2020 cycle compared to the 2016 cycle for all weight divisions, except for the 73kg in which there was an increase in the value (2020=2.1:1 vs. 2016=1.7:1). Figure 2 shows the significant difference when comparing the data in Table 2 between the weight divisions by Olympic cycle.

Regarding approach phase (Table 2; Fig. 2): In the combats that ended in RT ($p \leq 0.05$): a) within the 2016 cycle, the 100kg spent less time than 60, 73 and 81kg; b) within the 2020 cycle, the 60kg spent more approach time than 81 and 100kg; the 66kg spent more time than 73, 81 and 100kg; the >100kg spent less time than 60, 66, 73 and 90kg; c) between cycles, the 60kg(2020) spent less time than 60, 73, 81 and 90kg from 2016 cycle; the 90kg(2020) spent less time than 60, 66, 73, 81, 90 and 100kg from 2016 cycle; the 100 and 73kg(2020) spent less time than 60, 66, 73, 81, 90 and >100kg from 2016 cycle; the >100 and 81kg(2020) spent less time than all weight divisions from 2016 cycle.

In the combats that ended in GS ($p \leq 0.05$): a) within the 2016 cycle, the 66kg spent more time than 100kg; the >100 and 90kg spent less time in the approach phase than 60, 66 and 73kg; b) within the 2020 cycle, the 60kg spent more time than 81 and 100kg; the 66kg spent more time than 81, 90 and 100kg; the 73kg spent more time than 60, 81, 90 and 100kg; the >100kg spent less time than all weight divisions; c) between cycles, the 60kg(2020) spent more time than 90 and >100kg(2016); the 66 and 73kg(2020) spent more time than 81 and >100kg(2016); the 81kg(2020) spent less time than 66 and 73kg(2016); the 90kg(2020) spent more time than 90 and >100kg(2016); the 100kg(2020) spent less time than 66kg(2016); the >100kg(2020) spent less approach time than 60, 66, 73, 81 and 90kg from 2016 cycle.

Table 2. Time of combat phases of male judo, separating the combats by ending moment, between the 2016 and 2020 Olympic cycles (n=1380)

Weight divisions (combats per cycle)	Combat phases time (seconds) (mean ± standard deviation)												Effort/pause ratio		
	Approach		Gripping		Attack		Defense		Groundwork		Pause		RT	GS	
	RT	GS	RT	GS	RT	GS	RT	GS	RT	GS	RT	GS			
All categories (n=690)	80.9±40.2*	130.8±48.3	101.8±52*	167.1±55.4*	4.8±4.5*	10.5±7.2*	4.4±4.5*	8.6±6.3 [#]	40.4±28.8*	60.6±48 ^{&}	72±51.9 [‡]	140.5±75.5 [§]	3.2/1	2.6/1	
2016 cycle	60 kg (n=123)	85.8±37.7 [‡]	152.9±47	87.5±48.6*	109.8±34.8	5.1±4.6 [©]	13±4.4*	5±4.6 [#]	11.2±9.2 [§]	44.7±27.8 ^{©©}	74.9±25.3	74.3±45.2 ^{∞∞}	140.3±11.5	3.1/1	2.6/1
	66 kg (n=91)	78.5±31.8	169.8±73.4	91.5±45.2*	124.8±23.7	6.4±5.9*	13.3±7.7**	5.6±6.7*	11.6±8.1 [♠]	58.5±36.9*	121±107.4*	76.4±45.3	153.5±50.9	3.1/1	2.8/1
	73kg (n=100)	85.7±46*	171.4±11.2	94.6±51.5*	163.3±38.1	4.4±3.6	7.8±5.9	4±3.3 [∞]	8.6±3	33.7±26.5	61.7±14.3	66±45.4	245.3±240.4	3.4/1	1.7/1
	81 kg (n=102)	85.1±40.9*	125.4±25.2	108.5±48*	148.5±54.1	5.7±4.9*	14.8±6*	5.3±4.7*	11.9±5.8*	43.4±26.4*	75.2±23.5 [‡]	78.9±46.7	138.8±16.4	3.1/1	2.7/1
	90 kg (n=94)	81.8±36.5 [♠]	111±48.7 ^α	109.7±49.9*	191.8±42.7*	4.6±4	10.4±10.2 [#]	3.6±3.8	6.3±5.2	41.3±26.4	44.6±34.4	75.9±77.8	138.1±58.3	3.2/1	2.6/1
	100 kg (n=89)	71.1±37.9 [#]	110.7±5.9	101.4±51.4**	230.8±26.7 [#]	4.7±3.8 [®]	5.6±1.2	3.9±3.7 [^]	5.5±4.3	38.2±24.3**	37.3±22.6	70.7±57.4	100.6±8.2	3.1/1	3.9/1
	>100kg (n=91)	75.1±47.3*	125.4±25.2	125.1±60.8*	207.7±49.9	2.9±3	5.4±4.6	3±3.1	4.9±3.6	21.6±17.5	24.4±28.9	60.8±38.5	104.9±48.9 ^{αα}	3.7/1	3.5/1
All categories (n=690)	60.6±31.4*	140.6±55.1	65.2±38.9*	132.3±49.7*	3.3±2.8*	5.9±3.8*	2.8±2.7*	6.4±4.6 [#]	27.7±23.4*	49.9±31.5 ^{&}	62.2±56.6 [‡]	164.8±85.7 [§]	2.6/1	2/1	
2020 cycle	60 kg (n=123)	70±36.8 [‡]	148.4±56.8	48.6±31.9*	115±36.6	3.6±2.8 [©]	5.4±4*	3.2±2.6 [#]	6.9±5.6 [§]	35.1±29.9 ^{©©}	62.9±45.1	57.3±46.5 ^{∞∞}	155.5±86.5	2.8/1	2.2/1
	66 kg (n=91)	75.4±33.3	166±49.6	52.7±31.2*	106.2±36.3	3.3±3.1*	6.6±2.7**	2.6±3.1*	6.4±3.3 [♠]	31.4±22*	56.8±27.5*	56.9±49.4	175.9±98	2.9/1	1.9/1
	73kg (n=100)	62.3±29.3*	173.6±67.9	68.8±38.4*	118.4±33.1	3.4±2.9	6.5±3.8	2.8±2.6 [∞]	6.8±5.6	29.6±24	61.5±35	56±38.9	177±86	3/1	2.1/1
	81 kg (n=102)	54.3±26.9*	125.1±36.9	70.2±38.4*	156.4±58.4	2.9±2.9*	5.7±3.7*	2.7±2.6*	5.8±3.7*	24.1±19.3*	43.8±16.7 [‡]	65.5±47.8	167.2±93.2	2.4/1	2/1
	90 kg (n=94)	63.2±26.8 [♠]	144.7±36.8 ^α	65.6±32.6*	125.2±59.2*	3.5±2.7	5.7±3.5 [#]	3±2.6	6.7±4.5	32.2±24.5	44.1±21.8	78±90.2	154.3±62.4	2.1/1	2.1/1
	100 kg (n=89)	51.7±25.3 [#]	127.1±53.3	75.2±45.9**	146.1±41.7 [#]	3.4±2.5 [®]	6±4	2.6±2.7 [^]	5.9±4	24.1±20**	39.3±20	65.8±48.6	161.6±93.6	2.4/1	2/1
	>100kg (n=91)	47.4±29.9*	80.4±24.7	77.4±43.7*	184±37.1	3.1±2.9	5.7±5.5	2.3±2.6	5.6±5.6	16.8±14.6	31.9±24.4	58.2±64.3	168.5±82.8 ^{αα}	2.5/2	1.8/1

Significant difference between 2016 vs. 2020 cycle: *p<0.001; **p=0.001; #p=0.002; [♠]p=0.003; [‡]p=0.004; [‡]p=0.006; [©]p=0.007; ^{©©}p=0.01; [♠]p=0.014 [§]p=0.015; ^αp=0.021; ^{αα}p=0.022; [§]p=0.023; [&]p=0.032; [®]p=0.037; [∞]p=0.044; ^{∞∞}p=0.045; [^]p=0.049. RT – Regular Time; GS – Golden Score.

Combat phases/ cycle/ weight division		2016							2020						
		60kg	66kg	73kg	81kg	90kg	100kg	+100kg	60kg	66kg	73kg	81kg	90kg	100kg	+100kg
Groundwork – Regular time	2016 (n=690)	60 kg	*	μ				*	SS	μ	*	*	μ	*	*
		66 kg	*	*	*	*	*	*	*	*	*	*	*	*	*
		73kg	μ	*		ββ			*			ν		SS	*
		81 kg	*	*	ββ			*	ββ	Ω	**	*	S	*	*
		90 kg	*	*					*	μh	##	*	99	*	*
		100 kg	*	*					*			π			*
	2020 (n=690)	60 kg	SS	*		ββ		**			α		⊙	*	
	66 kg	μ	*		Ω	νh		μh					μ	*	
	73kg	*	*		**	##	α						μμ	*	
	81 kg	*	*	ν	*			*	α					*	
	90 kg	μ	*		S	99		&					**	*	
	100 kg	*	*	SS	*				⊙					*	
+100 kg	*	*	*	*	*	*	*	*	μ	μμ		**	*		
Groundwork – Golden Score	2016 (n=690)	60 kg		ΩΩ		Ψ	€€	**			β	SS	μμ	*	
		66 kg	ΩΩ		μμ	Ω	*	*	*	*	*	*	*	*	
		73kg		μμ			ξ							*	
		81 kg		Ω		L	99	**			Ω	##	μ	*	
		90 kg	Ψ	*		L								*	
		100 kg	€€	*		99								*	
	2020 (n=690)	60 kg		*			**			Ω	μ	**	*		
	66 kg		*				Ω				⊙⊙	**	*		
	73kg		*				μ			μh	π	#	*		
	81 kg	β	*		Ω		ΩΩ			νh	∞		*		
	90 kg	SS	*		##		#			∞			*		
	100 kg	μμ	*		μ		**	⊙⊙	#				*		
+100 kg	*	*		*		*	**	*				*			
Pause – Regular time	2016 (n=690)	60 kg													
		66 kg													
		73kg													
		81 kg													
		90 kg													
		100 kg													
	2020 (n=690)	60 kg													
	66 kg														
	73kg														
	81 kg														
	90 kg														
	100 kg														
+100 kg															
Pause – Golden Score	2016 (n=690)	60 kg													
		66 kg													
		73kg	⊙	€											
		81 kg				SS	ΩΩ	μμ	**	ββ		∞∞	ββ	L	99
		90 kg				SS									
		100 kg				ΩΩ									
	2020 (n=690)	60 kg													
	66 kg														
	73kg														
	81 kg														
	90 kg														
	100 kg														
+100 kg															

Fig. 2. Significant change in the time of combat phases of male judo, separating the combats by ending moment, between categories in the 2016 and 2020 Olympic cycle.

Significant difference: *p<0.001; **p=0.001; μp=0.002; μμp=0.003; #p=0.004; ##p=0.005; Ωp=0.006; ΩΩp=0.007; αp=0.008; Sp=0.009; SSp=0.01; βp=0.011; ββp=0.012; ⊙p=0.013; ⊙⊙p=0.014; &p=0.015; &&p=0.016; νp=0.017; ννp=0.018; *p=0.019; ∞p=0.02; ∞∞p=0.021; †p=0.022; ††p=0.023; ‡p=0.024; ‡‡p=0.025; †p=0.026; ††p=0.027; §p=0.028; §§p=0.029; Ψp=0.03; €p=0.031; €€p=0.032; @p=0.033; @@p=0.034; ‡p=0.035; ‡‡p=0.036; πp=0.037; ππp=0.038; ¶p=0.039; ¶¶p=0.043; €p=0.044; ; €€p=0.045; †p=0.046; †p=0.047; ††p=0.049; ^p=0.05.

In the gripping phase (Table 2; Fig. 2): In the combats that ended in RT ($p \leq 0.05$): a) within the 2016 cycle, the 60kg spent less time than 100kg; the 81 and 90kg spent more time than 60, 66 and 73kg; the >100kg spent more time than all weight divisions; b) within the 2020 cycle, the 60kg spent less time than 73, 81, 90, 100 and >100kg; the 66kg spent more gripping time than 73kg and less time than 81, 100 and >100kg; c) between cycles, the 60, 66, 73, 81 and 90kg from 2020 cycle spent less time than all weight divisions from 2016 cycle; the 100kg (2020) spent more time than 73kg (2016) and less time than 66, 81, 90, 100 and >100kg from 2016 cycle; the >100kg(2020) spent less time than 73, 81, 90, 100 and >100kg from 2016 cycle.

In the combats that ended in GS ($p \leq 0.05$): a) within the 2016 cycle, the 60 and 66kg spent less time in the gripping phase than 90, 100 and >100kg; the 81kg spent less time than 100 and >100kg; b) within the 2020 cycle, the 81kg spent more time than 60, 66, 73 and 90kg; the 100kg spent more time than 60, 66 and 73kg; the >100kg spent more time than all weight divisions; c) between cycles, the 90, 100 and >100kg from 2016 cycle spent more gripping time than 60, 66, 73, 81, 90 and 100kg from 2020 cycle; the 60kg (2020) spent less time than 73 and 81kg (2016); the 81kg (2020) spent more time than 60kg (2016); the >100kg (2020) spent more time than 60 and 66kg (2016).

Regarding attack phase (Table 2; Fig. 2): In the combats that ended in RT ($p \leq 0.05$): a) within the 2016 cycle, the 66kg spent more time than 60, 73, 90 and 100kg; the 81kg spent more time than 73kg; the >100kg spent less time than all weight divisions; b) between cycles, the 60, 66 and 81kg from 2016 cycle spent more attack time than all weight divisions from 2020 cycle; the 90kg (2016) spent more time than 66, 81 and >100kg from 2020 cycle; the 100kg (2016) spent more time than 66, 73, 81, 100 and >100kg from 2020 cycle.

In the combats that ended in GS ($p \leq 0.05$): a) within the 2016 cycle, the 81kg spent more time in the attack phase than 73, 90, 100 and >100kg; the 100kg spent less time than 60 and 66kg; the >100kg spent less time than 60, 66 and 90kg; b) between cycles, the 60, 66, 81 and 90kg from 2016 cycle spent more attack time than all weight divisions from 2020 cycle.

In the defense phase (Table 2; Fig. 2): For the combats that ended in RT ($p \leq 0.05$): a) within the 2016 cycle, the 60kg spent more time than 90 and >100kg; the 66 and 81kg spent more time than 73, 90, 100 and >100kg; b) between cycles, the 60, 66 and 81kg from 2016 cycle spent more time than all 2020 cycle weight divisions; the 73kg (2016) spent more time than 66, 73, 81, 100 and >100kg from 2020 cycle; the 90kg (2016) spent more time than >100kg (2020); the 100kg (2016) spent more time than 66, 81, 100 and >100kg from 2020 cycle. In the combats that ended in GS ($p \leq 0.05$): a) within the 2016 cycle, the 60, 66 and 81kg

spent more defense time than 90, 100 and >100kg; b) between cycles, the 60, 66 and 81kg from 2016 cycle spent more time than all 2020 cycle weight divisions.

Regarding groundwork phase (Table 2; Fig. 2): In the combats that ended in RT ($p \leq 0.05$): a) within the 2016 cycle, the 66kg spent more time than all weight divisions; the 73kg spent less time than 60 and 81kg; the >100kg spent less time than all weight divisions; b) within the 2020 cycle, the 60kg spent more groundwork time than 81, 100 and >100kg; the >100kg spent less time than 66, 73 and 90kg; c) between cycles, the 60, 66 and 81kg from 2016 cycle spent more time than all 2020 cycle weight divisions; the 73kg (2016) spent more time than 81, 100 and >100kg from 2020 cycle; the 90kg (2016) spent more time than all 2020 cycle weight divisions, except the 60kg (2020); the 100kg (2016) spent more time than 73 and >100kg (2020); the >100kg (2016) spent less time than 60, 66 and 90kg from 2020 cycle.

In the combats that ended in GS ($p \leq 0.05$): a) within the 2016 cycle, the 60kg spent more time than 90, 100 and >100kg; the 66kg spent more time than all weight divisions; the 73kg spent more time than >100kg; the 81kg spent more time than 90, 100 and >100kg; b) within the 2020 cycle, the 60kg spent more groundwork time than 81, 90, 100 and >100kg; the 66kg spent more time than 100 and >100kg; the 73kg spent more time than 81, 90, 100 and >100kg; c) between cycle, the 60 and 81kg (2016) spent more time than 81, 90, 100 and >100kg from 2020 cycle; the 66kg (2016) spent more time than all 2020 cycle weight divisions; the >100kg (2016) spent less time than 60, 66 and 73kg from 2020 cycle.

In the pause phase (Table 2; Fig. 2): For the combats that ended in RT ($p \leq 0.05$): a) within the 2016 cycle, the 81kg spent more time than 100kg; b) within the 2020 cycle, the 90kg spent more time than 60, 66 and 73kg; c) between cycle, the 60, 66 and 90kg from 2016 cycle spent more pause time than 60 and 73kg (2020); the 81kg (2016) spent more time than 60, 66, 73 and >100kg from 2020 cycle. In the combats that ended in GS ($p \leq 0.05$): a) within the 2016 cycle, the 73kg spent more time than all weight divisions; b) between cycles, the 73kg (2016) spent more time than 60, 81, 90, 100 and >100kg from 2020 cycle; the 100kg (2016) spent less time than 66 and 73kg (2020); the >100kg (2016) spent less time than 66, 73, 81, 100 and >100kg from 2020 cycle.

4. Discussion

In this study, we compared the duration of combat phases of male judo in international competitions between the 2016 and 2020 Olympic cycles, and by weight division. For a better

discussion of the results, we have divided two subchapters: a) Time of the combat phases between the 2016 and 2020 cycles; b) Time of the combat phases by weight division and between these cycles.

4.1. Time of the combat phases between the 2016 and 2020 cycles

Our main results showed that athletes from the 2020 cycle spent less time in the gripping, attack, defense and groundwork phases, and more time in the pause phase than in the 2016 cycle ($p \leq 0.001$) (Table 1). Considering that the regular combat time of male judo decreased from 5 to 4 minutes in the 2017 rule changes (IJF, 2017a), this data showed us an already expected reduction in the actual combat time; however, it is noteworthy that the pause time had increased and the time spent on the approach had not been changed with regular time reduction. This new demand for time in the judo combat phases resulted in a smaller effort/pause ratio in the 2020 cycle (2020=2.3:1 vs. 2016=3.1:1), in which athletes needed to perform intermittent efforts for a shorter period with a longer rest time.

Our data showed that the approach phase occupied 35.4% (83.6 ± 42.2 seconds) of the total combat time in the 2016 cycle, and although the regular combat time had been reduced in the 2020 cycle (IJF, 2017a), there was an increase in this percentage (39.7%; 82.2 ± 52.9 seconds). Therefore, in the 2020 cycle the approach phase seems to have become even more important in judo combat, as with a shorter regular time, the athlete needs to perform an efficient grip that allows the attack.

Previous study of male judokas classified for the 2012 Olympics also showed that the approach phase took up a large part of the total combat time: 109.1 ± 79.1 seconds (35.8% of total combat time from 548 combats) (Barreto, 2019). Thus, in this combat phase, athletes seek to dominate the *judogi* (uniform judo) before the opponent, to make an efficient grip to apply the favorite attack technique (*tokui-waza*). Furthermore, after getting the score, they could also use this phase strategically to avoid the opponent's grip and attacks and use up the total combat time.

However, when our data was analyzed separately at the end of combat, we observed that the 2020 athletes spent less time in all phases (including the approach and pause) of the combats that ended in RT compared to the 2016 cycle. On the other hand, in the analysis of the combats that ended in the GS, we found data similar to the general result of the combats: athletes from 2020 cycle spent less time in the gripping, attack, defense and groundwork phases, and more time in the pause phase in relation to the 2016 cycle (Table 2; Fig. 2). In other words, we identified that athletes who have adapted to the new rules and finish the

combats within the RT, manage to do it in less time than before, which consequently indicates greater attack efficiency. However, athletes who needed the GS, despite having spent lesser average combat time in the 2020 cycle, they performed shorter effort cycles with longer rest time and, consequently, extending the total time spent in a combat.

In the 2016 cycle, in case of a tie, the penalties could decide the winner of the combats at the end of RT (IJF, 2013; Barreto, 2022), however, this rule was changed in the 2020 cycle (IJF, 2017; IJF, 2017; Barreto, 2022). Thus, the strategy of inducing the opponent to commit fouls and administering them until the end of the RT was no longer useful to define the winner in the 2020 cycle. Therefore, the most efficient strategy to save energy for the next combats was to win as quickly as possible, especially in eliminatory combats, in which there is often a disparity between the athletes' competitive levels and a higher percentage of ippon victory (Ceylan, 2020). However, in the 2020 cycle, when the athletes could not win the combat within the RT, they needed the GS period (no time limit) until getting a score or the opponent's hansokumake (direct or by accumulating 3 Shido) (IJF, 2017; Barreto, 2022). This new demand for energy expenditure in combat imposed by the rule changes induced athletes to make the most of the pause time (rest), resulting in shorter efforts and longer pause times than in the 2016 cycle.

4.2. Time of the combat phases by weight division and between the 2016 and 2020 cycles

Analyzing the data by weight division is important to understand if what happens in the general analysis of the results coincides with the specific characteristics and behaviors of each weight group. Regarding the approach phase by weight division, the data are similar to the general analysis, we also found no significant difference comparing each weight division between cycles. This means that, at first sight, with the reduction in regular combat time, athletes of all weight divisions are proportionally spending more time in the approach phase in the 2020 cycle than in the 2016 cycle (60kg: 2016=38.1% vs. 2020=43.7%; 66kg: 2016=33.1% vs. 2020=47.1%; 73kg: 2016=38.7% vs. 2020=41.7%; 81kg: 2016=34.2% vs. 2020=35.9%; 90kg: 2016=33.5% vs. 2020=40.8%; 100kg: 2016=32.2% vs. 2020=35.8%), except in the >100kg (2016=32.8% vs. 2020=30%) (Table 1; Fig. 1). A study of male judokas qualified for the 2012 Olympics also showed that the approach phase occupied a large part of the total combat time in all weight divisions: 60kg=110.4 seconds (48.6% of total combat time from 77 combats); 66, 73 and 81kg=131 seconds (45.4% of total combat time from 412 combats); 90 and 100kg=128.7 seconds (39.3% of total combat time from 155 combats); >100kg=96 seconds (43.7% of the total combat time from 129 combats)(Sterkowicz-

Przybycień *et al.*, 2017). However, similarly to the general analysis, when we do a more detailed analysis separating the combats which ended within the RT from those that required GS, we observed that almost all weight divisions (except 66kg) had a reduction in the approach time in combats ended up to the RT, in the 2020 cycle compared to the 2016 cycle ($p \leq 0.05$). On the other hand, in combats that required GS, only the 90kg had a time increase in this phase ($p = 0.021$) (Table 2; Fig. 2).

In this detailed analysis it is important to emphasize the exceptions. The 66kg actually had a proportional increase in the time spent in the approach phase, and the 90kg had a significant time increase in this phase in combats that required GS. Knowing these new technical-tactical demands of athletes in these weight divisions in light of the rule changes is important for the specific prescription of judo training. In addition, in the 2020 cycle, the heavier categories seem to differ from the lighter categories. The heaviest categories from the 2020 cycle (>100, 100 and 81kg) spent less time in the approach phase than the lighter ones (Table 1; Fig. 1). In other words, heavier athletes needed less time to stabilize their *judogi* grip than lighter athletes.

In the analysis of the gripping phase, when we separated the general analysis by weight divisions, we observed a time reduction only in the 90 and >100kg in the 2020 cycle compared to the 2016 cycle ($p \leq 0.05$) (Table 1; Fig. 1). However, in the detailed analysis by end of combat, all weight divisions spent less gripping time in combats that ended in RT in the 2020 cycle than in the 2016 cycle, and the 90 and 100kg had reduced gripping time in combats that required GS ($p \leq 0.05$) (Table 2; Fig. 2). Previous data showed that lighter athletes differed from other weight divisions because they tended to spend more time in the approach phase making grip attempts, while heavier athletes used to spend more time in the gripping phase performed defensive grips (Barreto, 2019). However, our data showed that athletes able to define the combat within the RT, are either performing a more efficient grip to do an attack, or are giving up the grip performed faster and returning to the approach phase for a new gripping attempt. Moreover, although the 2020 cycle the heavier categories were still the ones that spent more time in the gripping phase compared to the lighter categories ($p \leq 0.05$) (Table 1; Fig.1), our detailed analysis shows a trend that their way of fighting has become increasingly dynamic.

Regarding attack, defense and the groundwork phases in the general analysis by weight divisions, the 2020 cycle athletes from the 66 and 81kg spent less time than the 2016 cycle athletes. In addition, while in the 2016 cycle there were differences between weight divisions for the attack and defense phases (66 and 81kg spent more time than other

categories), in the 2020 cycle there were no differences in these phases between weight divisions. Furthermore, in both cycles, the lighter categories (60 and 66kg) still spent more groundwork time and the >100kg spent less time in this phase than the other weight divisions (Table 1; Fig. 1). ($p \leq 0.05$) (Table 1; Fig. 1). In the detailed analysis by end of combat, in combats ended within the RT, the 60, 66, 81 and 100kg had a reduction in the attack, defense and groundwork time in the 2020 cycle compared to the 2016 cycle, and the 73kg had reduced defense time. In the combats that ended in the GS, time in the 2020 cycle compared to the 2016 cycle, the 60kg had a reduction in both defense and attack time, the 66 and 81kg spent less time in the attack, defense and groundwork phases, and the 90kg had reduced attack time ($p \leq 0.05$) (Table 2; Fig. 2). These data demonstrate that the shorter combat time established by the rule change reduced the time spent in both *Nage-waza* and *Ne-waza* attacks performed by athletes mainly in the 66 and 81kg.

In the pause phase, although in the general analysis there was a significant increase in the time spent in this phase in the 2020 cycle, when analyzed separately by weight division there was no significant difference between the cycles. However, there was a reduction in effort/pause for all the categories, and while in the 2016 cycle the >100kg had the highest effort/pause ratio (2016=3.7:1), in the 2020 cycle this was one of the weight divisions with the lowest effort/pause ratio (2020=2.2:1) (Table 1; Fig. 1). Furthermore, when we analyzed the data separated by end of combat, we observed that in the 2020 cycle there was a reduction in the pause time in combats that ended in RT and an increase in the time spent in this phase in combats that required GS. In a more detailed analysis, when we analyzed the combats by weight division and by end time, we verified that only the 60kg had a significant reduction in the pause time in the combats that ended in RT, and only the >100kg had a significant increase in the time spent in this phase in combats that ended in GS (Table 2; Fig. 2).

5. Conclusion

Our main results showed that, in the 2020 cycle compared to the 2016 cycle, there was a reduction in time for almost all combat action phases and an increase in the pause phase. However, the data from the present study suggest that the analyze of judo combat time and temporal effort demands should be made taking into account the differences between weight divisions and between end time of the combats. For a better understanding of the conclusions, we made a table (Table 3) that summarizes the temporal changes by weight division and end of combat in the 2020 cycle compared to the 2016 cycle.

Table 3. Significant changes in male judo combat phases in the 2020 Olympic cycle compared to the 2016 cycle ($p \leq 0.05$)

Weight division	Approach	Gripping	Attack	Defense	Groundwork	Pause
All weight divisions	--	↓	↓	↓	↓	↑
60 kg	--	--	--	--	--	--
66 kg	--	--	↓	↓	↓	--
73kg	--	--	--	--	--	--
81 kg	--	--	↓	↓	↓	--
90 kg	--	↓	--	--	--	--
100 kg	--	--	--	--	--	--
>100 kg	--	↓	--	--	--	--
Combats ended until the Regular Time						
Weight division	Approach	Gripping	Attack	Defense	Groundwork	Pause
All weight divisions	↓	↓	↓	↓	↓	↓
60 kg	↓	↓	↓	↓	↓	↓
66 kg	--	↓	↓	↓	↓	--
73kg	↓	↓	--	↓	--	--
81 kg	↓	↓	↓	↓	↓	--
90 kg	↓	↓	--	--	--	--
100 kg	↓	↓	↓	↓	↓	--
>100 kg	↓	↓	--	--	--	--
Combats ended in the <i>Golden Score</i>						
Weight division	Approach	Gripping	Attack	Defense	Groundwork	Pause
All weight divisions	--	↓	↓	↓	↓	↑
60 kg	--	--	↓	↓	--	--
66 kg	--	--	↓	↓	↓	--
73kg	--	--	--	--	--	--
81 kg	--	--	↓	↓	↓	--
90 kg	↑	↓	↓	--	--	--
100 kg	--	↓	--	--	--	--
>100 kg	--	--	--	--	--	↑

-- kept the average combat time; ↑ increased the average combat time; ↓ decreased the average combat time.

Our data showed that the approach phase became more relevant for athletes of 66kg and 90kg in light of recent rule changes. All weight divisions reduced gripping time in combats that ended up to Regular Time in the 2020 cycle, and the 90 and 100kg athletes also

needed less gripping time in *Golden Score* combats. The 60, 66, 81 and 100kg were the ones that most had their combat temporal behaviors modified (practically all combat phases had reduced time) comparing the 2020 cycle with the 2016 cycle. The >100kg showed the greatest change in the effort/pause ratio between the Olympic cycles, indicating a trend towards more dynamic combat behaviors. These data must be taken into account when prescribing male judo training aimed at performance, thus, the coach must identify the athlete's competitive profile (whether he usually needs *Golden Score* or not) and the physiological demands of his weight division for the prescribe specialized training.

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Authors' contributions

LBMB participated in the research concept and study design, literature review, data collection, data analysis and interpretation, statistical analyses and writing of the manuscript; BM and CJB participated in the research concept and study design, data analysis and interpretation, statistical analyses and writing of the manuscript.

Competing interests

The authors declare that they have no competing interests.

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6.4 ANÁLISE DO TEMPO DAS FASES DO COMBATE FEMININO E DA RELAÇÃO ESFORÇO-PAUSA POR DIVISÃO DE PESO E MOMENTO DE TÉRMINO ENTRE CICLOS OLÍMPICOS 2016 VERSUS 2020

Combat Time Phases of Female Judo between 2016 and 2020 Olympic Cycles

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Abstract

This study compared the time of female judo combat phases in international competitions between two Olympic cycles (2016; 2020), according weight divisions. We analyzed 1,332 female judo combat videos from two Olympic cycles (2016=666; 2020=666) from the top 20 in the World ranking by weight division. The main results showed that 2020 athletes spent less time in the attack ($p<0.001$), defense ($p<0.001$) and groundwork ($p=0.002$) phases than 2016 athletes. However, comparing by end-of-combat, 2020 athletes spent less time in all phases in combats ended until the Regular Time (RT) ($p<0.001$) and more time in the approach and gripping phases in combats ended in the *Golden Score* (GS) ($p<0.05$) than 2016 athletes. The 2016 weight divisions presented greater diversity in the effort/pause ratio values (2.5:1 to 3.4:1), while the 2020 weight divisions had values closer to each other (2.8:1 to 3:1). Analyzing each weight division separately and by end-of-combat, the main results showed that ($p<0.05$): 48,63,70,78kg reduced the time in almost every phase of combat in the RT (except for: 48,63kg=gripping; 70kg=groundwork; 78=approach); 48kg increased the gripping and groundwork time in GS combats; 78kg increased the approach and gripping time and reduced the groundwork time in GS combats. There were changes in the temporal behavior of the combats between the Olympic cycles with different rules when we analyzed them separated by weight division and by end-of-combat. These data must be taken into account to understand the characteristics of each group and to prescribe specialized training in female judo.

Keywords: martial arts; combat sports; time and motion studies; performance; task performance and analysis.

1. Introduction

To create more specific and therefore more efficient judo training, it is advisable to know each temporal phase of combat (Segedi *et al.* 2014, Sterkowicz-Przybycień, Miarka and Fukuda 2017), which can be classified into approach, gripping, attack, defense, groundwork and pause (Miarka *et al.* 2011, 2014). The technical-tactical behavior of athletes has been described by studies that temporally characterized the combat phases to identify which behaviors can predict the best sports performance (Kajmovic *et al.* 2014; Miarka *et al.*, 2014, 2016).

However, constant rule changes made by the International Judo Federation might have caused changes in the configuration of these temporal phases. In 2015, female judo combat time was reduced from 5 to 4 minutes (IJF, 2015), and in 2017-2018 *Yuko* score was abolished, the number of penalties (*Shido*) decreased from 4 to 3, in addition to no longer decide the winner at the end of the combat or in the *Golden Score* (IJF, 2017a, 2017b).

In this context, the objective of this study was to analyze the temporal phases of international female judo combats in two Olympic cycles (2016 vs. 2020) with different rules by weight division. The data from this study can be useful for judo coaches to plan training considering the temporal demand of each judo combat phase by weight division.

2. Methods

2.1. Sample

The present study analyzed 1,332 combat videos of female judo from two Olympic cycles (2016 vs. 2020) distributed in identical numbers by weight division (48kg=132; 52kg=72; 57kg=109; 63kg=96; 70kg=69; 78kg=106; >78kg=82; total=666 combats/cycle). The athletes analyzed were among the top 20 of each weight division in the World Ranking (ranking of May 30, 2016; March 16, 2020 -International Judo Federation). The 2016 cycle combats were collected after the 2015 rule change, so the regular combat time was 4 minutes. The 2020 cycle combats took place before the interruption of events due to the COVID-19 pandemic.

The combat videos were available for public access on the International Judo Federation's virtual channel; therefore, it was not necessary to obtain the informed consent of the athletes (American Psychological Association, 2002). The combats were from the following international judo competitions: 26 Grand Prix (Almaty 2016; Antalya 2019; Budapest 2015, 2016, 2019; Dusseldorf 2015, 2016; Havana 2016; Hohhot 2019; Jeju 2015;

Marrakech 2019; Montreal 2019; Qingdao 2015, 2016; Samsun 2015, 2016; Tashkent 2016, 2019; Tbilisi 2015, 2016, 2019; Tel Aviv 2019, 2020; Ulaanbaatar 2016; Zagreb 2016, 2019); 11 Grand Slam (Abu Dhabi 2015, 2016, 2019; Baku 2015, 2016, 2019; Paris 2016; Tokyo 2015, 2016; Tyumen 2015, 2016); 2 World Championship (Astana 2015; Tokyo 2019); and the Rio 2016 Olympic Games. The videos had a minimum quality of 480/60i and a panoramic view of the entire competition area.

2.2. Procedures

We used a validated analysis protocol for judo, which divided the judo combats into approach, gripping, attack, defense, groundwork and pause phases (Miarka *et al.* 2011, 2014, 2015). To analyze the videos we used the Frami® software, and the media player VLC 3.0.4 to make video compatible in this software. In this study, the time spent in each combat phase was established by weight division, by Olympic cycle (2016 vs. 2020), and by moment of combat end [Regular Time (RT) or *Golden Score* (GS)]. We also calculated the effort/pause ratio by dividing the sum of time spent in action phases by the pause time.

The videos were analyzed by a judo expert (>25 years of Judo, black 2nd Dan degree, national competitive experience) who performed a 12-hour training to learn to use the Frami® and the analysis protocol. Ando *et al.* (2016) demonstrated that the use of the judo analysis protocol has objectivity when performed by experts with at least a brown degree (1st Kyu). In fact, the reliability of the analysis was verified (20 judo combats reanalyzed 1 week later) and there was an “excellent” agreement for all combat phases (Intraclass Correlation Coefficient=0.95;0.99; Confidence Interval=0.88; 1).

2.3. Statistical Analysis

For statistical analysis, we used SPSS software (version 20.0; SPSS, Inc., Chicago, IL, USA) with a significance level of $p \leq 0.05$. The reliability of the use of the video analysis protocol was calculated by the Intraclass Correlation Coefficient test and confidence interval, as it is quantitative data. In the descriptive analysis of the temporal data of each judo combat phase (in seconds) we used mean, standard deviation and interval. We used Student's t test for independent samples in the data analysis by Olympic cycle, and ANOVA for independent factors in the analysis by weight division.

3. Results

Table 1 shows the time of each phase of female judo combat by Olympic cycle (2016 vs. 2020) and by weight division. Figure 1 demonstrates the comparison of data from Table 1 between weight divisions in each Olympic cycle.

Athletes spent less time in the attack ($p < 0.001$), defense ($p < 0.001$) and groundwork ($p = 0.002$) phases in the 2020 cycle than in the 2016 cycle. However, in the analysis by weight division, there was a significant difference only in the following situations between the Olympic cycles: a) attack phase in the 48kg ($p = 0.002$), the athletes of the 2020 cycle spent less time than those of the 2016 cycle; b) groundwork phase in the 78kg ($p = 0.008$), the athletes of the 2020 cycle spent less time than those of the 2016 cycle. In addition, in the 2016 cycle the lowest effort/pause ratio was in the 63kg (2.5:1) and the highest was in the 52kg (3.4:1), whereas, in the 2020 cycle there was a similarity in the effort/pause ratio between weight divisions (2.8:1 to 3:1) (Table 1).

Regarding approach phase: a) Within the 2016 cycle, there was a difference between: the 78 and >78kg spent less time than 48kg ($p < 0.001$); b) Within the 2020 cycle, there was a difference between: the 70kg spent less time than 48, 52 and 57kg; the 78kg spent less time than 48kg; and >78kg spent less time than 48, 52, 57 and 63kg ($p \leq 0.05$); c) Between the Olympic cycles: the 48, 52 and 57kg from 2020 cycle spent more time than 78 and >78kg(2016); 70kg(2020) spent less time than 48kg(2016); >78kg(2020) spent less time than 48 and 57kg(2016) ($p \leq 0.05$) (Table 1; Fig. 1).

In the gripping phase: a) Within the 2016 cycle, there was a difference between: the 48kg spent less time than 78 and >78kg; the 63kg spent less time than 78kg ($p \leq 0.05$); b) Within the 2020 cycle, there was a difference between: the 78kg spent more time than 52 and 70kg ($p \leq 0.05$); c) Between the Olympic cycles: the 48 and 52kg from 2020 cycle spent less time than 78kg(2016); 70kg(2020) spent less time than 57, 78 and >78kg from 2016 cycle; 78kg(2020) spent more time than 48kg(2016) ($p \leq 0.05$) (Table 1; Fig. 1).

Regarding attack phase: a) Within the 2016 cycle, there was a difference between: the 48kg spent more time than 57, 78 and >78kg ($p \leq 0.05$); b) Within the 2020 cycle, there was a difference between: the >78kg spent less time than 48 and 63kg ($p = 0.001$); c) Between the Olympic cycles: the 48kg(2016) spent more time than all 2020 weight divisions; >78kg(2020) spent less time than all 2016 weight divisions, except >78kg(2016) ($p \leq 0.05$) (Table 1; Fig. 1).

Table 1: Time of combat phases of female judo in the 2016 and 2020 Olympic cycles (n=1332)

Weight divisions (combats per cycle)	Combat phases time (seconds) (mean \pm standard deviation/ interval)						Effort/pause ratio	
	Approach	Gripping	Attack	Defense	Groundwork	Pause		
All categories (n=666)	69 \pm 38.2/ 250	76.2 \pm 42.9/ 289	4.7 \pm 4.2/ 29*	4.6 \pm 4.4/ 32*	49.9 \pm 31/ 207 ^{&}	73.3 \pm 54.4/ 345	2.7/1	
2016 cycle	48 kg (n=132)	86.3 \pm 39.1/ 227	63.4 \pm 30.6/ 143	6.3 \pm 5.2/ 29 ^{&}	6 \pm 5.5/ 32	64.1 \pm 25.7/ 137	83.3 \pm 47.5/ 215	2.7/1
	52 kg (n=72)	68.8 \pm 35.2/ 139	72.2 \pm 38.7/ 156	4.7 \pm 3.9/ 21	4.3 \pm 3.7/ 17	57.6 \pm 35/ 159	61.1 \pm 38.6/ 178	3.4/1
	57 kg (n=109)	70.8 \pm 43/ 250	80.6 \pm 48/ 289	4.3 \pm 3.9/ 19	4.3 \pm 3.9/ 17	43.4 \pm 32/ 151	65.6 \pm 46/ 188	3.1/1
	63 kg (n=96)	66.9 \pm 32.9/ 137	67.1 \pm 38.4/ 169	4.8 \pm 4.1/ 19	5.1 \pm 4.5/ 22	51.9 \pm 31.8/ 138	78.8 \pm 55/ 278	2.5/1
	70 kg (n=69)	67.1 \pm 42.7/ 182	74 \pm 40.7/ 189	4.4 \pm 4.1/ 21	4.5 \pm 4.3/ 23	46.4 \pm 30/ 122	72.6 \pm 66/ 339	2.7/1
	78 kg (n=106)	57.9 \pm 27.4/ 116	91.3 \pm 40.8/ 164	4.3 \pm 4.2/ 20	4.3 \pm 4.3/ 23	44.4 \pm 33/ 122 ^a	76.4 \pm 49/ 224	2.6/1
	>78 kg (n=82)	57.6 \pm 37.2/ 215	87.4 \pm 55.9/ 251	3 \pm 2.4/ 10	2.7 \pm 2.6/ 12	36.5 \pm 18.3/ 82	68.6 \pm 75.8/ 345	2.7/1
All categories (n=666)	72.8 \pm 51.4/ 309	72.2 \pm 50.2/ 321	3.6 \pm 3.3/ 23*	3.6 \pm 3.7/ 25*	45 \pm 34.1/ 186 ^{&}	69.3 \pm 60.9/ 314	2.8/1	
2020 cycle	48 kg (n=132)	86.8 \pm 55.3/ 259	70.2 \pm 44.4/ 201	4.4 \pm 3.9/ 17 ^{&}	4.5 \pm 4.2/ 22	59.7 \pm 38.6/ 183	81.3 \pm 70.9/ 270	2.8/1
	52 kg (n=72)	84.4 \pm 65.1/ 283	62 \pm 46.6/ 252	3.7 \pm 2.9/ 17	3.8 \pm 3.5/ 16	51.3 \pm 33.1/ 143	69.7 \pm 55.7/ 246	2.9/1
	57 kg (n=109)	83.4 \pm 61/ 309	78.2 \pm 55.5/ 223	3.8 \pm 3.8/ 23	3.8 \pm 4.1/ 25	55.8 \pm 35.2/ 174	78.4 \pm 67.9/ 314	2.9/1
	63 kg (n=96)	71.4 \pm 46.4/ 247	70.9 \pm 46.9/ 243	4.2 \pm 3.8/ 19	3.8 \pm 4.1/ 22	45.3 \pm 27.2/ 126	71.1 \pm 60.9/ 307	2.8/1
	70 kg (n=69)	57.5 \pm 35.8/ 155	55.9 \pm 45.7/ 205	3.1 \pm 2.7/ 13	3.2 \pm 3.7/ 22	43.1 \pm 37.4/ 183	54.9 \pm 48.4/ 186	3/1
	78 kg (n=106)	66.7 \pm 42.6/ 217	89.2 \pm 60.9/ 317	3.5 \pm 2.7/ 12	3.4 \pm 2.9/ 14	27.7 \pm 23.6/ 108 ^a	67.4 \pm 57.2/ 258	2.8/1
	>78 kg (n=82)	48.2 \pm 25.7/ 130	69.4 \pm 40/ 154	2.1 \pm 2.2/ 10	2.4 \pm 2.5/ 11	25.3 \pm 20.8/ 119	49.8 \pm 44.1/ 204	3/1

Significant difference between 2016 vs. 2020 cycle: *p<0.001; [&]p=0.002; ^ap=0.008

Combat phases/ cycle/ weight division		2016							2020							
		48kg	52kg	57kg	63kg	70kg	78kg	+78kg	48kg	52kg	57kg	63kg	70kg	78kg	+78kg	
Approach	2016 (n=666)	48 kg					*	*					**		*	
		52 kg														
		57kg													□	
		63 kg														
		70 kg														
		78 kg	*						*	β	μ					
		+78 kg	*						*	α	##					
	2020 (n=666)	48 kg					*	*					**	π	*	
		52 kg					β	α					∞		*	
		57kg					μ	##					SS		*	
		63 kg													π	
		70 kg	**						**	∞	SS					
		78 kg							π							
		+78 kg	*		□				*	*	*	π				
Grapple	2016 (n=666)	48 kg					*	α					μ			
		52 kg														
		57kg											ε			
		63 kg						∞								
		70 kg														
		78 kg	*			∞			α	μ			*		μ	
		+78 kg	α			∞				μ			*		μ	
	2020 (n=666)	48 kg						α						β		
		52 kg												β		
		57kg														
		63 kg														
		70 kg				ε		*		μ			*			
		78 kg	μ							β			*			
		+78 kg								β			*			
Groundwork	2016 (n=666)	48 kg					*					*	*	*	*	
		52 kg												*	*	
		57kg	*											α	Ω	
		63 kg												*	*	
		70 kg	β											α	μ	
		78 kg	*									ε		α	μ	
		+78 kg	*	μ								*	μ		μ	
	2020 (n=666)	48 kg												ε	*	*
		52 kg													*	*
		57kg													*	*
		63 kg	*									ε			μ	μ
		70 kg	*									∞				*
		78 kg	*	*	α			α	α			∞	*	*	μ	
		+78 kg	*	*	Ω	*		μ	μ			*	*	*	μ	*
Pause	2016 (n=666)	48 kg			#			μ	*			μ	*	*	*	
		52 kg													**	
		57kg	#												#	
		63 kg													*	
		70 kg													©	
		78 kg	μ												α	
		+78 kg	*												*	
	2020 (n=666)	48 kg	μ												**	
		52 kg	*													
		57kg	*													
		63 kg	μ												*	
		70 kg	*													
		78 kg	*													
		+78 kg	*	**	#	*	©	α		**		*				
Defense	2016 (n=666)	48 kg													*	
		52 kg													*	
		57kg													*	
		63 kg													**	
		70 kg														
		78 kg														
		+78 kg	*								α					
	2020 (n=666)	48 kg													©	
		52 kg														
		57kg														
		63 kg														
		70 kg														
		78 kg	*													
		+78 kg	*								**			©		
Pursue	2016 (n=666)	48 kg														
		52 kg													μ	
		57kg														
		63 kg														
		70 kg														
		78 kg														
		+78 kg														
	2020 (n=666)	48 kg													S	
		52 kg														
		57kg														
		63 kg														
		70 kg														
		78 kg														
		+78 kg	μ												S	

Fig. 1: Significant change in the time of combat phases of female judo between categories in the 2016 and 2020 Olympic cycle.

Significant difference: *p<0.001; **p=0.001; μp=0.002; μμp=0.003; #p=0.004; ##p=0.005; Ωp=0.006; αp=0.008; §p=0.009; §§p=0.01; βp=0.011; ββp=0.012; ©p=0.013; ©©p=0.014; &p=0.015; *p=0.019; ∞p=0.02; ∞∞p=0.026; ∞∞∞p=0.027; εp=0.028; §p=0.031; §p=0.037; μp=0.04; ∞p=0.041; πp=0.042.

In the defense phase: a) Within the 2016 cycle, there was a difference between: the >78kg spent less time than 48 and 63kg ($p \leq 0.05$); b) Within the 2020 cycle, there was a difference between: the 78kg spent less time than 48kg ($p = 0.014$); c) Between the Olympic cycles: the 48kg(2016) spent more time than all 2020 weight divisions, except 48kg(2020); the >78kg(2020) spent less time than 48 and 63kg(2016) ($p \leq 0.05$) (Table 1; Fig. 1).

Regarding groundwork phase: a) Within the 2016 cycle, there was a difference between: the 48kg spent more time than 57, 70, 78 and >78kg; and the 52kg spent more time than >78kg ($p \leq 0.05$); b) Within the 2020 cycle, there was a difference between: the 48kg spent more time than 63 and 70kg; the 78kg spent less time than 48, 52, 57 and 63kg; the >78kg spent less time than 48, 52, 57, 63 and 70kg ($p \leq 0.05$); c) Between the Olympic cycles: the 48kg(2016) spent more time than 63 and 70kg(2020); the 48kg(2020) spent more time than 57, 78 and >78kg from 2016 cycle; the 57kg(2020) spent more time than >78kg(2016); the 78 and >78kg(2020) spent less time than all 2016 weight divisions, except >78kg(2016) ($p \leq 0.05$) (Table 1; Fig. 1).

In the pause phase: a) Within the 2020 cycle, there was a difference between: the >78kg spent less time than 48kg ($p = 0.009$); b) Between the Olympic cycles: the >78kg(2020) spent less time than 48kg(2016) ($p = 0.003$) (Table 1; Fig. 1).

Table 2 shows the time of the combat phases that ended in RT or GS in each Olympic cycle (2016 x 2020) and by weight division. In combats that ended until RT, 2020 athletes spent less time in all combat phases compared to 2016 athletes ($p < 0.001$). On the other hand, in the combats that ended in the GS, the 2020 athletes spent more time in the approach and gripping phases than athletes from 2016 cycle ($p < 0.05$).

Analyzing by weight division there was a significant difference ($p < 0.05$) in the following combat phases (Table 2):

a) Combats that ended in RT, in the 2020 cycle compared to the 2016 cycle: the 48 and 63kg spent less time in the approach, attack, defense, groundwork and pause phases; the 52kg spent less time in the gripping phase; the 57kg spent less time in the attack; the 70kg spent less time in the approach, gripping, attack, defense and pause phases; the 78kg spent less time in the gripping, attack, defense, groundwork and pause phases; the >78kg spent less time in the gripping and groundwork phases.

b) Combats that ended in GS, in the 2020 cycle compared to the 2016 cycle: the 48kg spent more time in the gripping and groundwork phases; the 52 spent more time in the approach phase; the 57kg spent more time in the approach and groundwork phases; the 70 and

>78kg spent less time in the pause; the 78kg spent more time in the approach and gripping, and less time in the groundwork phase.

c) Although the effort/pause ratio varied by weight division in both cycles, in the 2020 cycle the values were closer between weight divisions. In the 2016 cycle, combats that ended in RT had the lowest value in the 63kg (2.5:1) and the highest in the 52kg (3.5:1), in the 2020 cycle the lowest effort/pause ratio was in the >78kg (2.9:1) and the highest also in the 48, 52 and 70kg (3.3:1). Furthermore, in the 2016 cycle, combats that ended in the GS had the lowest value in the 70 and >78kg (1.8:1) and the highest was also in the 52kg (3:1), while in the 2020 cycle the lowest effort/pause ratio was in the 48 and 63kg (2.4:1) and the highest in the >78kg (3.5:1) (Table 2). Figure 2 compares the data in Table 2 between weight divisions per Olympic cycle.

Regarding the approach phase (Table 2; Fig. 2):

a) In the combats that ended until RT ($p \leq 0.05$): a) Within the 2016 cycle: the 48kg spent more time than all weight divisions; the 78kg spent less time than 63kg; b) Within the 2020 cycle: the 48 and 57kg spent more time than 70, 78 and >78kg; c) Between cycles: the 48kg(2016) spent more time than all the weight divisions from 2020 cycle; the 70kg(2020) spent less time than 52, 57 and 63kg from 2016 cycle; the 78kg(2020) spent less time than 57 and 63kg(2016); the >78kg(2020) spent less time than 52, 57, 63, 70 and 78kg from 2016 cycle.

b) In the combats that ended in GS ($p \leq 0.05$): a) Within the 2016 cycle: the 48kg spent more time than 52, 57, 63 and 78kg; the 78kg spent less time than all weight divisions; b) Within the 2020 cycle: the 48kg spent less time than 52kg and more time than 70 and 78kg; the 52 and 57kg spent more time than 63, 70, 78 and >78kg; the 63kg spent more time than 70 and 78kg; c) Between cycles: the 48kg(2016) spent more time than 70 and 78kg(2020); the 78kg(2016) spent less time than all 2020 weight divisions, except >78kg(2020); the 48kg(2020) spent more time than 52, 57, 63 and 78kg from 2016 cycle; the 52kg(2020) spent more time than all 2016 weight divisions; the 57kg(2020) spent more time than all 2016 weight divisions, except 48kg(2016).

Table 2. Time of combat phases of female judo, separating the combats by ending moment, between the 2016 and 2020 Olympic cycles (n=1332).

Weight divisions (combats per cycle)	Combat phases time (seconds) (mean ± standard deviation)												Effort/pause ratio		
	Approach		Gripping		Attack		Defense		Groundwork		Pause		RT	GS	
	RT	GS	RT	GS	RT	GS	RT	GS	RT	GS	RT	GS			
All categories (n=666)	63.7±32.2*	123.3±49.9 [#]	72.2±39.2*	116.2±56.5 [∞]	4.4±4.1*	7.6±4.8	4.3±4.2*	7.2±4.8	47.4±28.9*	75.5±39.2	66.2±48.6*	145.3±57.7	2.9/1	2.3/1	
2016 cycle	48 kg (n=132)	78.2±149.7 [#]	149.7±48.1	62.7±30.9	68.6±28.7*	6±5*	8.6±6.2	5.7±5.4*	8.3±6	62.4±26.2*	78.1±16.3 [∞]	76.1±44.4*	139.7±30.5	2.8/1	2.2/1
	52 kg (n=72)	61.4±30.3	121.1±19.6*	66.3±35.8 ^β	114.2±33.1	4.2±3.4	8.4±4.9	3.7±3.1	8.3±5.1	52.5±32.4	93.6±33	53.3±32.3	115.7±35.8	3.5/1	3/1
	57 kg (n=109)	63.2±33.5	119±62.7*	70.8±38.4	141.8±57.4	3.8±3.8 ^ε	7.4±3.8	3.8±3.8	7.1±3.1	40±27.8	64.6±47.1 [♠]	53.5±34.2	141±39.1	3.4/1	2.4/1
	63 kg (n=96)	64.8±32 ^ε	104.5±26.6	63.3±35.1	136.6±30.3	4.7±4 [∪]	8.2±4.4	5±4.4*	7.2±5.9	52.1±31.9 [∪]	48.3±32.3	75.9±53.5 ^Ω	132.6±60.2	2.5/1	2.3/1
	70 kg (n=69)	59.5±37.3 [£]	124.7±38.1	69±36.6*	112.2±52	4±3.7 [®]	7.8±5.7	4±3.9 ^Ξ	8.3±5.3	42.8±28.6	74±27.7	57.8±44.2 ^{&}	185.1±96.1 [§]	3.1/1	1.8/1
	78 kg (n=106)	58.1±27.8	51.4±12.8 ^Ω	90.8±41*	108.1±32.4 [£]	4.3±4.2 ^Ξ	3.1±2.7	4.3±4.3 [∪]	3.4±3.4	41±26.2*	159.7±40.5*	75.1±48.7*	120.2±44.9	2.6/1	2.7/1
	>78 kg (n=82)	53.5±31.6	120.3±61.1	81.6±48.4 [¥]	176.1±91.1	2.8±2.3	6.2±1.9	2.7±2.7	3.2±1.5	35.9±18.5*	46.7±10.5	60.5±67.9	192.9±91.1 [£]	2.9/1	1.8/1
All categories (n=666)	55±30.5*	142.5±57.2 [#]	57.2±36.4*	130.9±54 [∞]	2.8±2.5*	6.7±4.3	2.8±2.7*	7.1±4.9	37.4±28.1*	74.9±39.1	49.8±42.5*	146±61.7	3.1/1	2.5/1	
2020 cycle	48 kg (n=132)	61.6±33.3 [#]	149±49.3	52.9±31.6	113.1±40.8*	3.1±2.8*	7.6±4.2	3.2±3.2*	7.6±4.8	44.6±26.7*	97.2±38.3 [∞]	50.8±47.1*	156.8±63.2	3.3/1	2.4/1
	52 kg (n=72)	58.7±32.1	174.4±72.2*	46.6±28.6 ^β	115.8±57.6	3±2	6.2±4.1	2.6±2.2	8.2±3.9	45.2±32.4	72.5±27.2	47.2±29.6	148.4±54.7	3.3/1	2.5/1
	57 kg (n=109)	62.8±36.1	164.9±71.5*	60.2±39.1	149.7±53.6	2.7±2.5 ^ε	7.9±5	2.9±2.8	7.3±6.1	47.1±28.7	90.1±38.1 [♠]	57.1±47.1	162.6±73.1	3.1/1	2.6/1
	63 kg (n=96)	53±26.1 [£]	137±43.8	57.4±36.5	119±49.3	3.4±3 [∪]	6.9±4.8	2.7±2.9*	7.7±5.3	39.8±24.9 [∪]	64.9±26.1	52.5±46.3 ^Ω	137.7±61.2	3/1	2.4/1
	70 kg (n=69)	47±25.2 [£]	107.3±37.4	41.4±30.7*	124.4±43.4	2.7±2.3 [®]	5.1±3.6	2.4±2.1 ^Ξ	7±6.3	34.6±30.5	83.8±41.6	38.9±34.1 ^{&}	131±29.8 [§]	3.3/1	2.5/1
	78 kg (n=106)	51.3±28.5	116.3±43.4 ^Ω	66.4±37.9*	163.2±63 [£]	3.1±2.2 ^Ξ	4.9±3.4	2.8±2.5 [∪]	5.1±3.3	25.3±24.7*	35.8±18.1*	48±38.5*	130.3±63.1	3.1/1	2.5/1
	>78 kg (n=82)	47.7±25.4	87.9±0	68.3±38.9 [¥]	159.8±0	2±2.1	6.5±0	2.3±2.6	3.9±0	25.3±20.9*	21.2±0	49.4±44.3	78.8±0 [£]	2.9/1	3.5/1

RT – Regular Time; GS – Golden Score.

Significant difference between 2016 vs. 2020 cycle: *p<0.001; #p=0.001; Ωp=0.002; ∪p=0.005; βp=0.006; ♠p=0.007; ∞p=0.008; §p=0.013; *p=0.018; Ξp=0.019; ∞p=0.02; £p=0.021; ∞p=0.025; ∪p=0.026; εp=0.029; &p=0.031; ¥p=0.033; ®p=0.045; £p=0.049.

In the gripping phase (Table 2; Fig. 2):

In the combats that ended until RT ($p \leq 0.05$): a) Within the 2016 cycle: the 78kg spent more time than all weight divisions, except >78kg; the >78kg spent more time than 48, 52 and 63kg; b) Within the 2020 cycle: the 57kg spent more time than 52 and 70kg; the 63kg spent more time than 70kg; the 78 and >78kg spent more time than 48, 52 and 70kg; c) Between cycles: the 78 and >78kg(2016) spent more time than all 2020 weight divisions; the 48kg(2020) spent less time than 52, 57, 70, 78 and >78kg from 2016 cycle; the 52 and 70kg(2020) spent less time than all 2016 weight divisions; the 63kg(2020) spent less time than 57, 78 and >78kg from 2016 cycle.

In the combats that ended in GS ($p \leq 0.05$): a) Within the 2016 cycle: the 48kg spent less time than all weight divisions, except 78kg; the >78kg spent more time than 48, 52, 70 and 78kg; b) Within the 2020 cycle: the 57kg spent more time than 48, 52 and 63kg; the 78kg spent more time than 48, 52, 63 and 70kg; c) Between cycles: the 48kg(2016) spent less time than all 2020 weight divisions; the >78kg(2016) spent more time than 48, 52, 63 and 70kg from 2020 cycle; the 48kg(2020) spent less time than 57 and >78kg(2016); the 57 and 78kg(2020) spent more time than 48, 52 and 70kg from 2016 cycle.

Regarding attack phase (Table 2; Fig. 2):

In the combats that ended until RT ($p \leq 0.05$): a) Within the 2016 cycle: the 48kg spent more time and the >78kg spent less time than all weight divisions; b) Within the 2020 cycle: the >78kg spent less time than 63kg; c) Between cycles: the 48kg(2016) spent more time than all 2020 weight divisions; the 48kg(2020) spent less time than 52, 63 and 78kg from 2016 cycle; the 52kg(2020) spent less time than 48, 63 and 78kg from 2016 cycle; the 57, 70 and >78kg from 2020 cycle spent less time than all weight divisions, except >78kg; the 78kg(2020) spent less time than 48, 52 and 63kg from 2016 cycle.

In the combats that ended in GS ($p \leq 0.05$): a) Within the 2016 cycle: the 78kg spent less time than 48, 52, 63 and 70kg; b) Within the 2020 cycle: the 70 and 78kg spent less time than 48 and 57kg; c) Between cycles: the 78kg(2016) spent less time than 48 and 57kg(2020); the 70kg(2020) spent less time than 48 and 52kg(2016); the 78kg(2020) spent less time than 48, 52, 57 and 70kg from 2016 cycle.

In the defense phase (Table 2; Fig. 2):

In the combats that ended until RT ($p \leq 0.05$): a) Within the 2016 cycle: the 48kg spent more time than all weight divisions, except 63kg; the 63kg spent more time than 52 and 57kg; the >78kg spent less time than all weight divisions, except 52kg; b) Between cycles: the 48, 63 and 78kg from 2016 cycle spent more time than all 2020 weight divisions; the 52kg(2020)

spent less time than 57 and 70kg(2016); the 63kg(2020) spent less time than 70kg(2016); the 70 and >78kg(2020) spent less time than all 2016 weight divisions, except >78kg.

In the combats that ended in GS ($p \leq 0.05$): a) Within the 2016 cycle: the 78kg spent less time than 48kg; the >78kg spent less time than 48, 52, 57 and 70kg; b) Within the 2020 cycle: the 78kg spent less time than 48, 52 and 63kg; c) Between cycles: the >78kg(2016) spent less time than 48, 52, 57 and 63kg from 2020 cycle; the 52kg(2020) spent more time than 78 and >78kg(2016); the 78kg(2020) spent less time than 48, 52 and 70kg from 2016 cycle.

Regarding groundwork phase (Table 2; Fig. 2):

In the combats that ended until RT ($p \leq 0.05$): a) Within the 2016 cycle: the 48kg spent more time than all weight divisions; the 52kg spent more time than 57, 78 and >78kg; the 63kg spent more time than 57, 70, 78 and >78kg; b) Within the 2020 cycle: the 70kg spent less time than 48, 52 and 57kg; the 78 and >78kg spent less time than 48, 52, 57 and 63kg; c) Between cycles: the 48kg(2016) spent more time than all 2020 weight divisions; the >78kg(2016) spent less time than 48 and 57kg(2020); the 63kg(2020) spent less time than 52kg(2016); the 70kg(2020) spent less time than 52 and 63kg(2016); the 78 and >78kg(2020) spent less time than all 2016 weight divisions.

In the combats that ended in GS ($p \leq 0.05$): a) Within the 2016 cycle: the 57kg spent less time than 52kg; the 63 and >78kg spent less time than 48 and 52kg; the 78kg spent more time than all weight divisions; b) Within the 2020 cycle: the 52kg spent less time than 48kg; the 63kg spent less time than 48 and 57kg; the 78kg spent less time than all weight divisions, except >78kg; the >78kg spent less time than 48, 52 and 70kg; c) Between cycles: the 78kg(2016) spent more time than all 2020 weight divisions; the 48kg(2020) spent more time than 57, 63, 70 and >78kg from 2016 cycle; the 57 and 70kg(2020) spent more time than 63 and >78kg(2016); the 63kg(2020) spent less time than 52kg(2016); the 78kg(2020) spent less time than 48, 52, 57 and 70kg from 2016 cycle; the >78kg(2020) spent less time than 48 and 52kg(2016).

In the pause phase (Table 2; Fig. 2):

In the combats that ended until RT ($p \leq 0.05$): a) Within the 2016 cycle: the 48, 63 and 78kg spent more time than 52, 57, 70 and >78kg; b) Within the 2020 cycle: the 70kg spent less time than 57kg; c) Between cycles: the 48, 63 and 78kg from 2016 cycle spent more time than all 2020 weight divisions; the 70kg(2020) spent less time than >78kg(2016).

Combat phases/ cycle/ weight division	2016							2020							Combat phases/ cycle/ weight division	2016							2020						
	48kg	52kg	57kg	63kg	70kg	78kg	+78kg	48kg	52kg	57kg	63kg	70kg	78kg	+78kg		48kg	52kg	57kg	63kg	70kg	78kg	+78kg							
Groundwork - Regular time	2016 (n=66)	48 kg		εε		*		*		*		*		*		*		*		*		*		*					
		52 kg	εε		Ω					μ		*	*	*		*		*		*		*		*					
		57 kg	*	Ω		##									**	**		*		*		*		*					
		63 kg	αα		αα		ππ	Ω	*			μμ	*	*	*		*		*		*		*	*					
		70 kg	*			ππ							*	*	*		*		*		*		*	*					
		78 kg	*	β		Ω									*	*		*		*		*		*					
		+78 kg	*	**		*			ππ		ξ				ψ	κ		*		*		*		*					
	2020 (n=66)	48 kg	*					ππ						α	*	*		*		*		*		*					
		52 kg	*											α	*	*		*		*		*		*					
		57 kg	*						ξ					α	*	*		*		*		*		*					
		63 kg	*	μ		μμ								α	*	*		*		*		*		*					
		70 kg	*	*		*		*	*	*	α	ππ	α		*	*		*		*		*		*					
		78 kg	*	*	**	*	*	*	ψ		*	*	*	**	**		*		*		*		*	*					
		+78 kg	*	*	**	*	*	*	κ		*	*	*	**	**		*		*		*		*	*					
Pause - Regular time	2016 (n=66)	48 kg																											
		52 kg																											
		57 kg																											
		63 kg																											
		70 kg																											
		78 kg																											
		+78 kg																											
	2020 (n=66)	48 kg																											
		52 kg																											
		57 kg																											
		63 kg																											
		70 kg																											
		78 kg																											
		+78 kg																											
Groundwork - Golden Score	2016 (n=66)	48 kg						€€		ξ			*	ξ		*		*		*		*		*					
		52 kg			ΔΔ	μ		*					*	ΔΔ		*		*		*		*		*					
		57 kg		ΔΔ		*		*							*		*		*		*		*	*					
		63 kg		μ		*		*						ψ		*		*		*		*		*					
		70 kg	*	*	*	*	*	*	α		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*				
		78 kg	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*				
		+78 kg	€€	##		*	*	*	*	*	*	α	*	ξ		*		*		*		*		*	*				
	2020 (n=66)	48 kg	ξ				α	*	*		##																		
		52 kg					*	*			##																		
		57 kg				ΩΩ	##	*	*	α																			
		63 kg		ξ		*	*	*	*	*	*	##																	
		70 kg	*	*	*	ψ	*	*	Δ		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*				
		78 kg	*	*	*	*	**	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*				
		+78 kg	ξ	ΔΔ		*	*	*	*	ΩΩ		€€		ξ		*		*		*		*		*	*				
Pause - Golden Score	2016 (n=66)	48 kg						€€		ξ			*	ξ		*		*		*		*		*					
		52 kg																											
		57 kg																											
		63 kg																											
		70 kg																											
		78 kg																											
		+78 kg																											
	2020 (n=66)	48 kg							€€		ξ			*	ξ		*		*		*		*		*				
		52 kg																											
		57 kg																											
		63 kg																											
		70 kg																											
		78 kg																											
		+78 kg																											

Fig. 2. Significant change in the time of combat phases of female judo, separating the combats by ending moment, between categories in the 2016 and 2020 Olympic cycle.

Significant difference: *p<0.001; **p=0.001; #p=0.002; ##p=0.003; μp=0.004; μμp=0.005; Ωp=0.006; ΩΩp=0.007; αp=0.008; ααp=0.009; ζp=0.01; βp=0.011; ββp=0.012; &p=0.013; &&p=0.014; ©p=0.015; ©©p=0.016; ψp=0.017; *p=0.018; ∞p=0.019; ∞∞p=0.02; †p=0.021; ††p=0.022; ‡p=0.023; ‡‡p=0.024; §p=0.025; §§p=0.026; §§§p=0.027; ^p=0.028; €p=0.029; €€p=0.03; †p=0.031; ††p=0.032; ∞p=0.033; ∞∞p=0.034; ∞∞∞p=0.035; ∞p=0.036; ∞∞p=0.037; §p=0.038; §§p=0.039; †p=0.04; ††p=0.041; †††p=0.042; πp=0.043; ππp=0.044; ∞p=0.045; ∞∞p=0.046; ∞p=0.047; ∞∞p=0.048; †p=0.049; ††p=0.05.

In the combats that ended in GS (p≤0.05): a) Within the 2016 cycle: the 70kg spent more time than 48, 52, 57 and 78kg; the >78kg spent more time than all weight divisions, except 70kg; b) Within the 2020 cycle: the 78kg spent less time than 48 and 57kg; c) Between cycles: the 52kg(2016) spent less time than 48 and 57kg(2020); the 70kg(2016) spent more time than 63, 78 and >78kg from 2016 cycle; the >78kg(2016) spent more time than 63, 70 and 78kg from 2016 cycle.

4. Discussion

This study compared the time of female judo combat phases in international competitions between the 2016 and 2020 Olympic cycles, by weight division and by moment of the end of combat. For a more organized discussion of the results, we have divided two subchapters: a) Time of combat phases; b) Time of combat phases by end moment.

4.1. Time of the combat phases

Our main results showed that athletes from the 2020 cycle spent less time in the attack, defense and groundwork phases than in the 2016 cycle ($p \leq 0.05$). In the other words, a reduction in the offensive phases of combat. However, when analyzed by weight division, there was a difference only in one category and in the phases of attack (48kg: $p=0.002$) and groundwork (78kg: $p=0.008$). In addition, while in the general analysis we observed a similar effort/pause ratio between Olympic cycles (2016=2.7:1; 2020=2.8:1), in the analysis by weight division in the 2016 cycle there was diversity in the effort/pause ratio (\downarrow value: 63kg=2.5:1; \uparrow value: 52kg=3.4:1), whereas in the 2020 cycle there was a similarity in the effort/pause ratio between weight divisions (2.8:1 to 3:1) (Table 1). These data show that it is important to carry out specific analyzes by weight category, for a better understanding of the time demand of combats.

Despite the rule changes between the Olympic cycles, some similarities were found in the temporal demand between the weight divisions. Both in the 2016 cycle and in the 2020 cycle ($p \leq 0.05$): a) The 48kg spent more time in the attack [48kg vs. 57,78,>78kg(2016); vs. >78kg(2020)], defense [48kg vs. >78kg(2016); vs. 78kg(2020)] and groundwork phases [48kg vs. 57,70,78,>78kg(2016); vs. 63,70kg(2020)] than other weight divisions; b) The heavier categories (78,>78kg) spent less time in the approach phase [78,>78kg vs. 48kg(2016); vs. 48kg(2020); and >78kg vs. 52,57,63kg(2020)] than the lighter categories; b) The 78kg spent more time in the gripping phase [78kg vs. 48,63kg(2016); vs. 52,70kg(2020)] than other weight divisions; c) The >78kg spent less time in the groundwork phase [>78kg vs. 52kg(2016); vs. 48,52,57,63,70kg(2020)] than other weight divisions (Table 1; Fig. 1). These data demonstrate that, regardless of the rule in force in the Olympic cycle, heavier female categories spend little time to master the judogi (uniform judo), more time maintaining the grip and little time performing offensive actions.

This behavior is probably due to the physical wear and tear caused by the grip dispute and the attack actions, in addition to the movement speed/body mass ratio. Thus, athletes with

greater body mass, strategically spend more time maintaining the grip and positioning their body in the best way to carry out the attack, since if the attack is not successful, the risk of losing the combat on the groundwork will be great, mainly due to immobilization. Ceylan and Balci (2020) analyzed combats from 2018 to 2019 and observed that 5 of the 6 combats in the +78kg ended with *Ippon* before the end of the regular time. Adam *et al.* (2013) observed that the highest groundwork attack efficiency index of the 2012 women's Olympic champions was in the heavy categories (efficiency index: 63kg=6, 70kg=1.3, 78kg=5 vs. 48,52,57kg=0).

On the other hand, athletes with lower body mass, who are generally more agile and quick in their movements, need to spend more time in the approach phase to perform an efficient grip and apply immediate attack techniques, making it difficult for the opponent to defend. Sterkowicz-Przybycien *et al.* (2017) analyzed athletes from international competitions from 2011-2012, and they showed that lighter categories spent more time in the approach [median(interquartile range): 48kg=98.7(96.5); 52,57,63kg=106.6(112) vs. 70,78kg=81.8(94.7) seconds] and groundwork phases [median(interquartile range): 48kg=39.6(59.3); 52,57,63kg=15.1(36.3); 70,78kg=11.8(31.1) seconds], and less time in the defense phase [median(interquartile range): 48kg=4.3(7.1); 52,57,63kg=6.8(14.1); 70,78kg=7.5(18.5) seconds] than heavier categories. Adam *et al.* (2013) found that the 2012 Olympic champions of the lightest categories had greater versatility in applying techniques than the heavier categories (attack versatility index: 48kg=32; 52kg=26; 57kg=44; 63kg=34 vs. 70kg=10; >78kg=16), except for the 78kg (attack versatility index=42).

In addition to that, the approach and gripping phases can be used to manage combat time and avoid the opponent's attacks after obtaining a score. Thus, the data suggest that the light and heavy weight divisions could be using different strategies to manage combat time. Balci & Ceylan (2020) analyzed 2018-2019 Senior World Judo Championships, and they found that the number of penalties increased with the higher the weight division, and that the most committed prohibited actions were non-combativity (common for those who hold the grip without making attacks) and avoid-grip (common for those who spend a lot of time in the approach phase). In this sense, we suggest that future studies analyze the reasons for penalties separated by weight division.

4.2. Time of the combat phases by end moment

When analyzing the total time of the combat phases by weight divisions between Olympic cycles, it seems that the rule changes did not substantially interfere in the female combat time, since as demonstrated in the previous subchapter, there were many temporal similarities

between the cycles. However, when we analyze the combats by the moment they ended (RT vs. GS), we can verify that in the combats ended until the RT, the 2020 athletes spent less time in all combat phases compared to the 2016 cycle ($p < 0.001$), and in the combats ended in the GS, the 2020 athletes spent more time in the approach and gripping phases than the athletes of the 2016 cycle ($p < 0.05$) (Table 2). That is, we identified that there was a change in temporal behavior between the Olympic cycles.

Analyzing by weight division, the main results showed that in the 2020 cycle compared to the 2016 cycle: a) the 48, 63, 70 and 78kg reduced the time in almost all phases in the combats ended up to the RT; b) in combats ended in the GS: some categories increased the time in the approach (52, 57, 78kg) and gripping (48, 78kg) phases; although in the analysis of the total weight divisions between the cycles there was no significant difference for the groundwork, in the analysis by weight division the 48kg and 57kg increased its time, and the 78kg reduced the time in this phase; c) there were no changes between the Olympic cycles for the offensive (attack and groundwork) and defensive phases in combats ended in the GS for any weight division (Table 2).

The reduction in the time of phases in combats end up to RT and the increase in time spent in non-offensive phases (approach and gripping) in combats ended in GS can be explained by the rule changes that occurred between the Olympic cycles. In the 2020 cycle, penalties no longer decided the winner of the combats ended in the RT, and in case GS occurs, only accumulating 3 *Shido* would result in defeat (IJF, 2017a, 2017b; Barreto, 2022), unlike the 2016 cycle, when in case of a tie in the RT, the existing penalties, or in the GS, the 1st *Shido*, determined the winner (IJF, 2013; Barreto, 2022).

Therefore, the best strategy in the 2020 cycle became to win as quickly as possible to avoid the GS, which explains the time reduction that we found in combats ended up to the RT (48, 63, 70 and 78kg). In addition, these combats probably had a shorter duration in the 2020 cycle than in 2016. This can be demonstrated by the increase in the effort/pause ratio for these weight divisions in the 2020 cycle (48kg: 2016=2.8:1 vs. 2020=3.3:1; 63kg: 2016=2.5:1 vs. 2020=3:1; 70kg: 2016=3.1:1 vs. 2020=3.3:1; 78kg: 2016=2.6:1 vs. 2020=3.1:1) (Table 2), which suggests fewer combat interruptions in the 2020 cycle than in the 2016 cycle. On the other hand, in the 2020 cycle, athletes unable to perform efficient attacks in RT and who needed GS, spent more time in the non-offensive phases (48, 52, 57 and 78kg), because only an efficient attack or the accumulation of 3 *Shido*, rather than the 1st *Shido* in the 2016 cycle, would determine the combat winner (IJF, 2013, 2017a, 2017b; Barreto, 2022).

Furthermore, as there was no change in the times spent in the offensive (attack and base) and defensive phases of the combats ended in the GS for any weight division between the Olympic cycles, we believe that the rule changes did not boost the performance of actions offensives in GS. In addition, the fact that there was no difference between groundwork time in the GS between Olympic cycles in the analysis of all weight divisions together, and that there were differences in the analysis separated by weight (48, 57kg increased; 78kg reduced), highlights the importance of understanding what happens in each weight division separately, in order to prepare for more specific workouts.

Comparing the combats between weight divisions, separated by end moment and by Olympic cycle, the similarities found in both cycles were: a) The 57, 78 and >78 kg spent the most time in the gripping phase (both RT and GS); b) The >78kg spent the least time on the attack in the combats ended in the RT, and the 78kg in the combats ended in the GS; c) The >78kg spent the least time on the groundwork (both RT and GS) (Table 2; Fig. 2).

However, we also found changes from one Olympic cycle to another: a) While in the 2016 cycle the 48kg spent the most time in the approach phase, in the 2020 cycle this only occurred in comparison with the heaviest categories, that is, the 52 and 57kg had values close to those of the 48kg (both RT and GS); b) While in the 2016 cycle, the >78kg spent the least time on defense, in the 2020 cycle there was no difference between >78kg and others (both RT and GS); c) While in the 2016 cycle, the 78kg spent the most time in groundwork in the combats ended in GS, in the 2020 cycle they were one of the weight divisions that spent less time at this phase; d) While in the 2016 cycle, the 70 and +78 kg spent the most time in the pause phase, in the 2020 cycle, they spent the least time in this phase (Table 2; Fig. 2).

Our data showed that there were some changes in temporal behaviors between cycles in some weight divisions. However, a limitation of our study was that we only present temporal data of the combat phases. In view of these findings, it is necessary to qualitatively understand which actions (type of approach, grip and techniques) were performed by the athletes in each Olympic cycle. Therefore, we intend to publish more studies with a qualitative technical-tactical analysis of combats from different Olympic cycles.

5. Conclusion

In a general analysis, we found that the athletes from 2020 cycle reduced the time spent on offensive actions (attack, defense and groundwork) compared to the 2016 cycle. In addition, the weight divisions in the 2016 cycle presented greater diversity in the values of the

effort/pause ratio (2.5:1 to 3.4:1), while those of the 2020 cycle had values closer to each other (2.8:1 to 3:1). However, it was only when we analyzed the combats by weight division and end-of-combat time that we were able to specifically detect how these changes occurred. We created a table (Table 3) that summarizes the main temporal changes by Olympic cycle found in this study.

Table 3. Significant changes in female judo combat phases in the 2020 Olympic cycle compared to the 2016 cycle ($p \leq 0.05$)

Weight division	Approach	Gripping	Attack	Defense	Groundwork	Pause
All weight divisions	--	--	↓	↓	↓	--
48 kg	--	--	↓	--	--	--
52 kg	--	--	--	--	--	--
57kg	--	--	--	--	--	--
63 kg	--	--	--	--	--	--
70 kg	--	--	--	--	--	--
78 kg	--	--	--	--	↓	--
>78 kg	--	--	--	--	--	--
Combats ended until the Regular Time						
Weight division	Approach	Gripping	Attack	Defense	Groundwork	Pause
All weight divisions	↓	↓	↓	↓	↓	↓
48 kg	↓	--	↓	↓	↓	↓
52 kg	--	↓	--	--	--	--
57kg	--	--	↓	--	--	--
63 kg	↓	--	↓	↓	↓	↓
70 kg	↓	↓	↓	↓	--	↓
78 kg	--	↓	↓	↓	↓	↓
>78 kg	--	↓	--	--	↓	--
Combats ended in the <i>Golden Score</i>						
Weight division	Approach	Gripping	Attack	Defense	Groundwork	Pause
All weight divisions	↑	↑	--	--	--	--
48 kg	--	↑	--	--	↑	--
52 kg	↑	--	--	--	--	--
57kg	↑	--	--	--	↑	--
63 kg	--	--	--	--	--	--
70 kg	--	--	--	--	--	↓
78 kg	↑	↑	--	--	↓	--
>78 kg	--	--	--	--	--	↓

-- kept the average combat time; ↑ increased the average combat time; ↓ decreased the average combat time.

Thus, in combats that ended up to Regular Time, 2020 athletes spent less time in all combat phases compared to the 2016 cycle, indicating that athletes were able to win combat faster than they did before. In the combats that ended in the Golden Score, the 2020 athletes

spent more time in the non-offensive phases (approach and gripping) than 2016 cycle, which suggests the search for the opposing penalty at the expense of *Ippon*.

In the analysis of each category separately and by end-of-combat, the main results showed that in 2020 cycle compared to 2016: a) The 48kg reduced the time in almost every phase of combat (except gripping) in the Regular Time, and increased the gripping and groundwork time in the Golden Score; b) The 63 and 70kg reduced the time in almost every phase of combat in the Regular Time (except for: 63kg= gripping; 70kg= groundwork); c) The 78kg reduced the time in almost every phase of combat (except approach) in the Regular Time, and in the Golden Score: increased the approach and gripping time, reduced the groundwork time and they were who spent the least time on attack in both cycles.

To sum up, there was a change in the temporal behavior of the combats between the Olympic cycles with different rules. However, our main results showed that it is important to perform specific analyzes by weight division and separating athletes who usually finish the combat in Regular Time from those who usually require Golden Score in order to understand the characteristics of each group.

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Authors' contributions

LBMB participated in the research concept and study design, literature review, data collection, data analysis and interpretation, statistical analyses and writing of the manuscript; BM and CJB participated in the research concept and study design, data analysis and interpretation, statistical analyses and writing of the manuscript.

Competing interests

The authors declare that they have no competing interests.

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7 CONSIDERAÇÕES FINAIS

Este estudo verificou o impacto das modificações das regras do judô de dois ciclos Olímpicos (2016 e 2020) sobre o comportamento temporal de combates internacionais masculinos e femininos. Inicialmente, foram escritos 3 artigos de revisão para melhor compreensão sobre a evolução das regras do judô ao longo dos últimos anos e levantamento do conhecimento existente na literatura sobre o tempo de combates de judô masculino e feminino à nível internacional. Posteriormente, foi verificada a confiabilidade da expert em judô por meio da análise de 20 vídeos e realizado um estudo piloto com 680 combates masculinos, para consolidação dos procedimentos, materiais e métodos estatísticos utilizados nesta pesquisa. Felizmente, o estudo piloto permitiu compreender previamente que seria necessário realizar uma análise dos dados separando os combates por momento de término (Tempo regular versus *Golden Score*), haja vista o considerável aumento na ocorrência e no tempo gasto no *Golden Score* no ciclo 2020.

Desse modo, foi realizada a análise dos dados de 2712 vídeos (1332 lutas femininas: 666 por ciclo; 1380 lutas masculinas: 690 por ciclo olímpico) dos 20 primeiros atletas ranqueados mundialmente em cada categoria de peso, para cada sexo, em cada ciclo. Esses dados resultaram na elaboração de 4 artigos científicos, que analisaram o tempo total, as fases temporais e a relação esforço-pausa dos combates de judô masculino e feminino entre os ciclos olímpicos 2016 e 2020, comparando as divisões de peso e considerando o momento de término dos combates.

Nas Tabelas 3 e 4 encontra-se um resumo dos principais resultados desta tese para uma melhor visualização. No ciclo 2020 houve redução do tempo total de combate masculino, com redução das fases de pegada, ataque, defesa e solo, porém com um aumento na fase de pausa. Analisando por fim do combate, houve redução do tempo gasto em combates finalizados até o Tempo Regular e aumento na ocorrência e no tempo gasto em combates terminados no *Golden Score*. Analisando as categorias de peso observou-se que todas reduziram o tempo de pegada em combates que terminaram até o Tempo Regular. Além disso, no ciclo 2020:

- a) <60kg diminuíram o tempo e ocorrência de combates que terminaram dentro do Tempo Regular, reduzindo o tempo em todas as fases do combate; e aumentaram o tempo e ocorrência de combates que acabaram no *Golden Score*, porém diminuíram o tempo gasto no ataque e na defesa;

Table 3 - Significant changes in the temporal demands of male and female judo combats in the 2020 Olympic cycle compared to the 2016 cycle.

Changes in the 2020 Olympic cycle compared to the 2016 Olympic cycle										
Weight division	Combat time	Effort/pause ratio	RT	RT%	Effort/pause ratio	RT	GS	GS%	Effort/pause ratio	GS
Male (n=1380)	60 kg	--	↓	↓	↓	↓	↑	↑	↓	↓
	66 kg	--	↓	↓	↓	↓	↓	↑	↓	↓
	73kg	--	↓	↓	↓	↓	--	↑	↑	↑
	81 kg	↓	↓	↓	↓	↓	↑	↑	↓	↓
	90 kg	--	↓	↓	↓	↓	↑	↑	↓	↓
	100 kg	--	↓	↓	↓	↓	--	↑	↓	↓
	>100 kg	↓	↓	↓	↓	↓	--	↑	↓	↓
Female (n=1332)	48 kg	--	↑	↓	↑	↑	↑	↑	↑	↑
	52 kg	--	↓	--	↓	↓	↑	--	↓	↓
	57kg	--	↓	--	↓	↓	↑	--	↑	↑
	63 kg	--	↑	↓	↑	↑	↑	↑	↑	↑
	70 kg	--	↑	↓	↑	↑	--	--	↑	↑
	78 kg	--	↑	↓	↑	↑	--	↑	↑	↑
	>78kg	--	↑	↓	--	--	↓	--	↑	↑

RT - Time of combats that ended until regular time; RT% - Occurrence of combats that ended until regular time; GS - Time of combats that required the Golden Score; GS% - Occurrence of combats that required the Golden Score; -- maintenance between Olympic cycles; ↑ increased in the 2020 Olympic cycle compared to the 2016 Olympic cycle; ↓ decreased in the 2020 Olympic cycle compared to the 2016 Olympic cycle.

Fonte: Dados parciais de BARRETO *et al.*, 2022c e dados da tese elaborado pelo autor (2022).

Table 4 - Significant changes in the temporal phases of male and female judo combats in the 2020 Olympic cycle compared to the 2016 cycle.

Changes in the 2020 Olympic cycle compared to the 2016 Olympic cycle																			
Weight division	Total combat time						Time of combats that ended until regular time						Time of combats that required the Golden Score						
	AP	GP	AT	DE	GR	PA	AP	GP	AT	DE	GR	PA	AP	GP	AT	DE	GR	PA	
Male (n=1380)	60 kg	--	--	--	--	--	↓	↓	↓	↓	↓	↓	--	--	↓	↓	--	--	
	66 kg	--	--	↓	↓	↓	--	↓	↓	↓	↓	--	--	--	↓	↓	↓	--	
	73kg	--	--	--	--	--	↓	↓	--	↓	--	--	--	--	--	--	--	--	
	81 kg	--	--	↓	↓	↓	--	↓	↓	↓	↓	--	--	--	↓	↓	↓	--	
	90 kg	--	↓	--	--	--	--	↓	↓	--	--	--	↑	↓	↓	--	--	--	
	100 kg	--	--	--	--	--	--	↓	↓	↓	↓	--	--	↓	--	--	--	--	
	>100 kg	--	↓	--	--	--	--	↓	↓	--	--	--	--	--	--	--	--	--	↑
Female (n=1332)	48 kg	--	--	↓	--	--	↓	--	↓	↓	↓	↓	--	↑	--	--	↑	--	
	52 kg	--	--	--	--	--	--	↓	--	--	--	--	↑	--	--	--	--	--	
	57kg	--	--	--	--	--	--	--	↓	--	--	--	↑	--	--	--	↑	--	
	63 kg	--	--	--	--	--	--	↓	--	↓	↓	↓	--	--	--	--	--	--	
	70 kg	--	--	--	--	--	--	↓	↓	↓	↓	--	↓	--	--	--	--	↓	
	78 kg	--	--	--	--	↓	--	--	↓	↓	↓	↓	↑	↑	--	--	↓	--	
	>78kg	--	--	--	--	--	--	--	↓	--	↓	--	--	--	--	--	--	--	↓

AP – Approach phase; GP – Gripping phase; AT – Attack phase; DE – Defense phase; GR – Groundwork phase; PA – Pause phase; -- maintenance between Olympic cycles; ↑ increased in the 2020 Olympic cycle compared to the 2016 Olympic cycle; ↓ decreased in the 2020 Olympic cycle compared to the 2016 Olympic cycle.

Fonte: Dados parciais de BARRETO *et al.*, 2022c e dados da tese elaborado pelo autor (2022).

- b) <66kg diminuíram o tempo e a ocorrência de combates que terminaram até o Tempo Regular, com redução do tempo gasto nas fases de pegada, ataque, defesa e solo; diminuíram o tempo de combates que terminaram no *Golden Score*, com redução do tempo gasto no ataque e na defesa, porém aumentaram a ocorrência de *Golden Score*;
- c) <73kg diminuíram o tempo e ocorrência de combates que terminaram dentro do Tempo Regular, com redução do tempo gasto na aproximação, pegada e defesa; e aumentaram a ocorrência de *Golden Score*, porém sem alteração significativa do tempo gasto;
- d) <81kg diminuíram o tempo total de combate; reduziram o tempo e ocorrência de combates que terminaram no Tempo Regular, reduzindo quase todas as fases do combate (exceto pausa); aumentaram o tempo e ocorrência de combates que terminaram no *Golden Score*, porém com redução do tempo gasto nas fases de ataque, defesa e solo;
- e) <90kg diminuíram o tempo e ocorrência de combates que terminaram dentro do Tempo Regular, com redução do tempo gasto na aproximação e pegada; e aumentaram o tempo e ocorrência de combates que acabaram no *Golden Score*, com aumento do tempo gasto na aproximação, mas com redução do tempo da pegada e ataque;
- f) <100kg diminuíram o tempo e ocorrência de combates que terminaram dentro do Tempo Regular, reduzindo quase todas as fases do combate (exceto pausa); aumentaram a ocorrência de *Golden Score*, com redução do tempo gasto na pegada;
- g) >100kg diminuíram o tempo total de combate e ocorrência de combates que terminaram dentro do Tempo Regular, com redução do tempo gasto na aproximação e pegada; aumentaram a ocorrência de combates que terminaram no *Golden Score*, com aumento do tempo gasto na pausa. Essa categoria foi a que apresentou maior redução na relação esforço-pausa no ciclo 2020, com esforços mais curtos por tempo de pausa.

No ciclo 2020, em uma análise geral, não houve redução do tempo total de combate feminino, porém, constatamos redução do tempo gasto em ações ofensivas (ataque, defesa e

solo). As divisões de peso do ciclo 2016 apresentaram maior diversidade nos valores da relação esforço-pausa, enquanto as do ciclo 2020 apresentaram valores mais próximos entre si. Quando os combates foram analisados pelo momento em que terminaram, no ciclo 2020 houve redução do tempo nos combates que terminaram até o Tempo Regular, com menos tempo gasto em todas as fases de combate, e aumento no tempo de combates que terminaram no *Golden Score*, com aumento de tempo nas fases de aproximação e pegada. Na análise por divisão de peso, em combates que terminaram até o Tempo Regular, houve redução do tempo para quase todas (exceto <57kg), e para combates que terminaram no *Golden Score* houve aumento do tempo para os pesos mais leves (<48kg, <52kg, <57kg e <63kg). A categoria >78kg foi a única que reduziu o tempo tanto em combates de Tempo Regular como no *Golden Score*. Assim, no ciclo 2020:

- a) <48kg diminuíram o tempo e ocorrência de combates que terminaram dentro do Tempo Regular, reduzindo quase todas as fases do combate (exceto pegada); e aumentaram o tempo e ocorrência de combates que acabaram no *Golden Score*, com maior tempo nas fases de pegada e solo;
- b) <52kg diminuíram o tempo de combates que terminaram até o Tempo Regular, com redução da fase de pegada; aumentaram o tempo de combates que terminaram no *Golden Score*, com maior tempo de aproximação;
- c) <57kg não alteraram o tempo gasto em combates que terminaram até o Tempo Regular, porém, tiveram redução na fase de ataque; aumentaram o tempo de *Golden Score*, com maior tempo de aproximação e solo;
- d) <63kg reduziram o tempo e ocorrência de combates que terminaram até o Tempo Regular, reduzindo quase todas as fases do combate (exceto pegada); aumentaram o tempo e ocorrência de combates que terminaram no *Golden Score*, porém, não houve alteração nas fases temporais para estes combates;
- e) <70kg diminuíram o tempo de combates que terminaram dentro do Tempo Regular, reduzindo quase todas as fases do combate (exceto solo); não alteraram o tempo gasto em combates que terminaram no *Golden Score*, porém, tiveram redução na fase de pausa.
- f) <78kg diminuíram o tempo e ocorrência de combates que terminaram dentro do Tempo Regular, reduzindo quase todas as fases do combate (exceto aproximação);

aumentaram a ocorrência de *Golden Score*, com aumento das fases de aproximação e pegada e redução do tempo gasto no solo;

- g) >78kg diminuíram o tempo total de combate de combates que terminaram dentro do Tempo Regular, com redução do tempo gasto na pegada e solo; diminuíram o tempo gasto em combates que terminaram no *Golden Score*, com redução do tempo gasto na pausa.

Os dados encontrados nesse estudo apontam para diferenças temporais dos combates entre as divisões de peso tanto na categoria masculina quanto na feminina, portanto, o treinador deve ser cauteloso ao agrupar treinos de atletas de pesos distintos. Por exemplo, agrupar atletas de <78kg, que tiveram maior ocorrência de *Golden Score* no ciclo 2020 com aumento do tempo gasto na aproximação e pegada, com atletas do >78kg. Diferentes comportamentos temporais de combate requerem demandas de energia distintas para performance.

Os resultados deste estudo sugerem que os atletas masculinos e femininos de 2020, que terminavam o combate dentro do Tempo Regular, conseguiam vencer mais rápido que os do ciclo de 2016, indicando que as mudanças da regra os estimularam evitar o *Golden Score*. Porém, muitos não conseguiam, daí o aumento na ocorrência do *Golden Score* no ciclo 2020. Além disso, os atletas que terminavam os combates no *Golden Score* no ciclo 2020 necessitavam de mais tempo para vencer o combate que os atletas do ciclo 2016, sugerindo que apesar da mudança das regras, os atletas ainda buscavam a penalidade adversária em detrimento do *Ippon*, já que em vez de uma penalidade no ciclo 2020 era necessário completar os 3 *Shido* para que o oponente perdesse (desclassificação).

Os dados desse estudo devem ser levados em consideração na prescrição do treinamento do judô feminino e masculino, para uma adaptação mais específica da carga de trabalho. Sugere-se também compreender o perfil competitivo dos atletas aos quais o treinamento é direcionado, se eles costumam terminar seus combates no Tempo Regular ou no *Golden Score*, para entender as demandas temporais individuais de esforço e planejar estratégias técnico-táticas específicas para cada atleta.

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